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ABSTRACT

Military manned space systems have gone through a painful evolution. A brief review is made of the history of such systems, including the Dyna-soar and Manned Orbiting Laboratory programs. The results of the Apollo program are discussed. Recent high level policy declarations are reviewed including a letter from the Air Force Chief of Staff and two Presidential directives. Results of theoretical studies on the utility of manned systems are reviewed, leading into a discussion of manned military space missions that are either planned or being considered.

INTRODUCTION

The words Strategic Deterrence conjure visions of ICBMs on alert for retaliation, or F-106s to counter bomber attacks. It is easy to fall back on past experience and knowledge, and so hard to look forward. The familiar is so comfortable, but in today's rapidly changing environment perhaps we need to be considering the unfamiliar as a path to establishing the strategic balance.

Adlai Stevenson told a story about how President Roosevelt in 1937 wanted to get the best estimate of the scientific community as to what was coming in the next decade, and as Stevenson describes the result, he found himself "on a par with the greatest scientific minds of the time . . . . for I, too, failed to foresee nuclear energy, antibiotics radar, the electronic computer and rocketry".[1] What is the lesson? It is that in the past, we have been too conservative in our projections for the future. We demand more preciseness in describing the threat upon which requirements for new systems can be based. We are asked for detailed information on projected system capabilities costs and schedules when in fact we can only dimly perceive the shape of the future environment. The well known, well published difficulties we are having in developing a basing strategy for the MX is certainly a good example of how hard it is to cope with the future, using extensions of today's systems.

Perhaps we need to devote attention to more imaginative systems of the future; systems that fly higher, faster, have global range and that really extend man's military capabilities and potential to react. Manned space system fit in that category.

MANNED SPACE SYSTEMS BACKGROUND

It seems strange that there has been so much controversy over manned space systems. You might argue that the Dynasoar program was too far ahead of its time, that it pushed technology too much and that its payload capabilities and life cycle costs did not support continuing the program. You might also argue the same points for the Manned Orbiting Laboratory (MOL) program. Those arguments are moot, however, because we'll never know for sure what the positive results of those programs might have been. Given the rapid change in the balance of power today in hindsight we may wish we had pursued such innovative programs more vigorously.

When the MOL program was cancelled, it was felt the Apollo program would demonstrate some of the utilities of man-in-space that the military was interested in. However, it turned out there few such objectivies or tests associated with Apollo. Furthermore, there was no indepth study by the military of the results of Apollo until 1978, nine years after the Apollo 11 astronauts first stepped on the moon. Vietnam certainly had us pre-occupied at that time, but I don't believe that is the main reason we were so uninterested in the lessons learned from Apollo. Characteristically, the military is very conservative in nature and just as the Army was very uninterested in the airplane in 1910, so the corporate Air Force has been relatively uninterested in space. But on a more positive side, within the last 18 months things have started to change.

RECENT POLICY STATEMENTS

In May 1977, the Air Force Chief of Staff signed out a letter to all major commands entitled "Air Force Space Policy". It referred to our growing reliance on space operations which is accompanied by a growing threat to the free use of space.

The letter affirms that among prime Air Force responsibilities are activities in space related to the development of weapons systems, military operations and the defense of the United States conducted in accordance with national policy and international law. The letter strongly supports the need for the Air Force to protect the free use of space by providing needed space defense capabilities.

This letter by the Chief represents the first formal declaration of top Air Force policy on space in quite a long time. Not long after, there were two presidential directives published that established U.S. policy on both civil and military space activities.[2] They included the same thrusts of the Chief's letter and not unsurprisingly gave manned space systems such as the Shuttle and Spacelab strong support. For military Shuttle operations, the directive states, "The STS will service all authorized space users—domestic and foreign, commercial and governmental—and will provide launch priority and necessary security to national security missions while recognizing the essentially open character of the civil space program". These two directives cover a broad range of policies including space defense, satellite systems survivability, remote sensing, technology sharing and the convergence of military and civil space activities to name just a few. The directives merit close study by all of us.

LESSONS LEARNED FROM MANNED SPACE PROGRAMS

The accomplishments of the Mercury, Gemini, Apollo and Skylab programs are fairly well known, but let me provide just a brief summary as a reminder.

The first basic fact is that man is capable of operating effectively in low earth orbit for extended periods of time. Based on the Skylab experience and the more recent Soviet accomplishments, we feel that manned orbital operations of up to six months should be no problem. We do need to understand the bone demineralization phenomena better before we can predict how long man may eventually work in a zero "G" environment. When talking about manned space operations at geosynchronous altitude, a period of 30 days seems to be "ballpark". I say "ballpark" because we still do not have the necessary data on the ionizing radiation environment in those orbits to make a more accurate judgement. The 30 day period is based on reasonable shielding approaches with the understanding that solar flares may call for bio-wells with wall thicknesses of one inch. Such flares can be predicted from 30 minutes to 12 hours ahead of time.

The second lesson is that man-on-the-scene lends tremendously increased operational effectiveness to complicated and unforeseen tasks. When the Skylab solar telescope missions were being planned, we envisioned man as being on the scene only to throw the necessary switches as planned. This quickly became an obsolete mode of operation. You cannot effectively pre-plan an R&D or an operatinal mission when you are not sure of what you will see and when you will see it. The astronauts soon became experts at the identification of scientifically important phenomena. They captured valuable data during fleeting moments of opportunity and made many other on the spot judgments which enhanced the entire mission. Figure 1 shows a dramatic solar storm that was captured on film largely because an astronaut was on hand to recognize that something important was occurring and to take appropriate action. The results of Skylab showed uneuqivocally the value of allowing highly trained crewmen to act independently on the basis of their observations of patterns, trends, and resultant extrapolations which are not possible with automated equipment. Other excellent examples of astronaut capabilities include the complex repair of the coolant loop system on Skylab. On Apollo 13, the astronauts devised ingenious workarounds, which saved their lives and the mission, after their spacecraft was damaged by the rupture of a high pressure system. During the final descent phase to the moon, the on-board computer of the Apollo 11 Lunar Lander became overloaded. Manual override and control by the astronaut saved the mission which otherwise would have been aborted.

The Commander of the first Skylab mission repaired an inoperative power relay by rapping it with a hammer during a routine spacewalk. The manual deployment of the jammed solar panel on Skylab and the erection of the solar shade by Astronaut Pete Conrad saved that very important and expensive mission. Pete used a crowbar and deployed the solar array that was jammed, to use his words by "one lousy bolt". This is perhaps the best example of how man is indispensable in situations that on the surface appear quite simple but which no automated system can cope with.

Astronauts have also been exceptionally effective in rendezvous and docking. Their successes stand out in sharp contrast to the problems that the Soviets experienced in the past with their automated rendezvous and docking systems. Station keeping with another spacecraft and the alignment of inertial reference platforms are two other functions that crewmen on-the-scene have performed exceptionally well.

FUNCTIONAL SUPERIORITIES AND LIMITATIONS OF MAN

Theoretical studies have been performed on man's superior functional performance compared to automated systems.[3] The results of these studies have had fairly limited distribution and understanding within the militarv. NASA on the other hand accepts almost as an article of faith that manned space capabilities are not only essential to the future economic, social, and military well being of our nation, but in fact are almost mandatory. Let's look for a moment at the functional superiorities and limitations of man.

The human eye-mind combination is a wonderful synergism. What cannot be seen at first glance can be seen later by virtue of the mind integrating a series of incomplete or hazy visual images. Our forward air controllers in Vietnam would miss a target hidden under jungle foliage on the first pass, but after circling an area of interest, the sum of hundreds of images from different angles, aspects and lighting conditions would reveal the existence of a target that would have otherwise been missed. This same phenomena was identified by the astronauts and is key to our understanding of the values of man, on-the-scene, in space.

There are many limitations of the human eye which can be compensated for by the use of automated equipment. The image residence time of approximately 1/16 second limits our ability to distinguish rapid changes in a scene. A high speed camera can compensate for this. The eye is sensitive to a narrow band of frequencies bounded by the ultraviolet and infrared spectra; therefore, we employ systems that can detect those wave lengths. Even with its limitations, there are three ways in which the eye and eye/mind combination are superior:

DYNAMIC RANGE is a measure of the widest difference in feature brightness that can co-exist in a field of view without causing degraded preception of any feature. The eye is superior to all equipment and detectors that function in the visible spectrum in this respect. The astronauts found that their pictures from space looked washed out and did not record feature details of texture and hue that were so clearly evident to the unaided eye. In several cases, such as the Comet Kohoutek, items that were clearly visible to the eye did not show up in the picture.

Man excels at PATTERN RECOGNITION. The human observer possesses extraordinary talent to recognize patterns or configurations that correlate with the familiar or contrast with the norm. It is nearly impossible to incorporate active, real time pattern discrimination in the design of automated equipment.

Man also excels at TEXTURE IDENTIFICATION. The eye is not perfect in making textural distinctions but is far superior to any automated equipment in differentiating between ice, snow, and clouds for example.

These next two figures summarize all of the functions that man does well, either by himself or in combination with other systems.[4] The bottom line is that there are many such functions that cannot be automated. The human eye-brain-hand system is by far the most flexible and versatile data analysis and servo system ever launched into space. It gives us an ad hoc response capability wherein we can detect, interpret and react in real time to unprogrammed events or opportunities. This is an important consideration.

I know that these two figures are very busy and they are included only to make the point that there are a great number of diverse functions, all of which we take for granted, that man does exceedingly well, which either cannot be automated or which would cost much more to automate. A shorter list of those which I believe are the more important functions include: aligning, analyzing, assembling, deploying, devising workarounds, docking, prioritizing, experimenting, analyzing malfunctions and repairing, inspecting, launching and recovering, maneuvering, monitoring, recovering payloads and replacing parts. In sum, what can be done by man comprises a long list and all of the permutations and combinations of these functions probably approach infinity. That is one reason we have so much trouble addressing the subject.

MANNED MILITARY SPACE MISSIONS

What military missions can be enhanced, or more importantly, enabled by man-in-space? From the past discussion some of these missions will be obvious and other less so. Let's start with the most straightforward ones.

In space transportation, the man-in-the-loop allows the system to be recovered and reused. This has a large cost benefit. With man, payloads can be deployed, checked out and, if required, returned to the launch site. We can also deploy such satellites as the Long Duration Exposure Facility wherein experiments are exposed to the Space environment for extended periods of time, measured in years and then recovered for analysis. Likewise satellites that have failed in orbit can be recovered for detailed failure analysis. These are all significant new capabilities and the few I have mentioned are just the tip of the iceberg.

Military R&D is an area which man in space may well revolutionize. Let me cite a few potential examples. We cannot derive as accurate trajectory information or impact prediction data as desired from our ICBM warning satellites. There is the possibility that the signal-to-noise ratio of an ultraviolet (UV) sensor sensing missile plumes during spaceflight would allow improved detection and tracking. The earth essentially looks black to a UV sensor in space. However, we have not been able to get the necessary ultraviolet plume signature data from space using automated systems. We think that a manned system, perhaps Spacelab, using essentially off-the-shelf hardware may well be able to coordinate operations such that a man could identify a launch, point the systems, lock on, ajdust the field of view to maximize the value of observed data, test and select various filters, operate other sensors in parallel for data correlation, annotate the data, etc., in such a way that for the first time, good UV plume signature data may be acquired in minimum time and at minimum cost. It turns out that the astronauts of Gemini Five and Seven demonstrated pointing and tracking using small IR systems and got good data on Minuteman III and Polaris launches, and they tracked a ground sled launch as well as the plume for a reentry vehicle.[5] So you can see that we are not talking about anything very radical or new.

Experience shows we seldom set out to solve a specific problem in a laboratory and end up with the point solution. Rather, the scientist experiments, observes certain phenomena which leads him down new paths to new important and not necessarily unrelated discoveries. We need to provide our scientists that capability in space. This is admittedly high risk technology but with a very high potential payoff. The acquisition of a space lab to perform experimentation that could benefit various mission areas may be warranted and deserves consideration.

We think that man can contribute greatly to space test efforts in addition to the data and phenomenology activities already mentioned. In general, it appears that if you stay with the approach of using an automated spacecraft it takes up to six years to design, develop, and test-in-space the first proof of concept system. With a manned approach you could conceivably launch a brassboard model in about two years or less, an engineering development model in a year later and a system prototype in another year.[6] In sum, we have the potential for schedule compression, lower overall costs, and three tests instead of one, which benefit from a learning curve and more reliable and meaningful data.

SUMMARY

The United States has always been known as the leader in technology. We all are aware that today we are losing that edge to the Japanese, Germans, and other innovative friendly and unfriendly competitors. Due to budget realities, we have to rely on quality rather than quantity in our armaments.

The Apollo program is given extremely high marks for improving our nation's overall technology which bolstered our economy and improved our military. The Space Shuttle is the next step in the right direction.

As discussed there are several valuable experiments that could be accomplished by military crews in space. There are many more that could be discussed that are classified.

Our deterrence is based upon our power. An old quote says that, "Before it is used, power is what people think it is". Therefore, our power has to be credible in that the Soviets have to believe we would use it, if provoked. Space systems provide a great deal of the communications and information required to "use" our power.

No one knew that Colombus, Lewis and Clark or the Wright Brothers would achieve before their successes, and they certainly had their critics. So today we are still a little unsure of what manned space systems will bring. We can say, however, that everytime man explored the unknown, or travelled higher and faster it has turned out to be very beneficial to that particular society.

I predict that manned space systems will provide at least the same quantum jump in military capabilities as did the airplane. We must not take as long to embrace space as it took to exploit air.

In summary, it is most important to maintain an excellent technology base, especially in the new regime of space, so that we can be flexible and responsive to any emerging requirement or threat. For as General Van Moltke said, "you will usually find that the enemy has three courses of action open to him. Of these, he will pick the fourth."

REFERENCES

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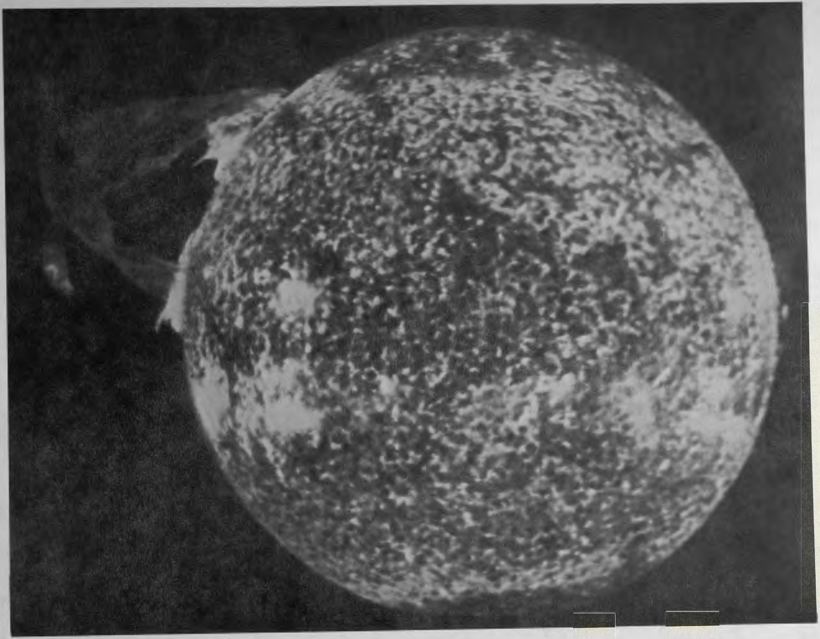

Figure 1.

FUNCTIONS WHICH CAN BE PERFORMED BY MAN FOR EACH DISCIPLINE AREA AND ALL OF THE INITIATIVES

DISCIPLINE AREA \ FUNCTION PERFORMED	ADJUST EQUIPMENT	ALIGN STRUCTURES	ANALYZE DATA	ASSEMBLE PARTS	ATTACH SUBSTRUCTURES	CALIBRATE INSTRUMENTS	CHANGE SUBSYSTEMS	CHECK ASSEMBLIES
I. SCIENTIFIC RESEARCH	2	4	4	3		2	3	
II. ENGINEERING AND TECH. OPERATIONS	2	4	4	4	4		4	3
III. COMPUTER AND AUTOMATION TECH.			4				3	
IV. DEVELOPMENT AND TECHNOLOGY		2	4	4	4		4	3
V. MONITORING AND SERVICE FUNCTIONS	2	2	4	4		1	4	
VI. MEDICAL AND BIO. STUDIES			4					
VII. FLIGHT OPERATIONS			4					

DISCIPLINE AREA \ FUNCTION PERFORMED	COMMUNICATE AND CONFER	COMPUTER PROGRAMMING	CONTAMINATION CONTROL	COORDINATE OPERATIONS	DELIVER MATERIAL & PARTS	DEPLOY SYSTEMS & PAYLOAD	DEVELOP & PROCESS DATA	DEVISE "WORK-AROUNDS"
I. SCIENTIFIC RESEARCH	4	2	4	3		4	2	3
II. ENGINEERING AND TECH. OPERATIONS	3				4	4		4
III. COMPUTER AND AUTOMATION TECH.	4	3		1			1	4
IV. DEVELOPMENT AND TECHNOLOGY	3	3	4		4		2	3
V. MONITORING AND SERVICE FUNCTIONS	4	3	4	1		4		4
VI. MEDICAL AND BIO. STUDIES	3	3						
VII. FLIGHT OPERATIONS	4	3		4		4		

DISCIPLINE AREA \ FUNCTION PERFORMED	DISTRIBUTE RESULTS	DOCK WITH SPACE SYSTEMS	ESTABLISH OPERATION MODE	ESTABLISH PRIORITIES	EVALUATE RESULTS	EXPERIMENT	FABRICATE STRUCTURES	FLIGHT CREW MANAGEMENT
I. SCIENTIFIC RESEARCH	4		4	3	3	3		
II. ENGINEERING AND TECH. OPERATIONS							4	
III. COMPUTER AND AUTOMATION TECH.	1			2	1			
IV. DEVELOPMENT AND TECHNOLOGY			4		3	3	4	
V. MONITORING AND SERVICE FUNCTIONS	1	2	3	3				
VI. MEDICAL AND BIO. STUDIES	1							
VII. FLIGHT OPERATIONS		4	3					3

DISCIPLINE AREA \ FUNCTION PERFORMED	FLIGHT OPERATIONS	FOOD PREPARATION	GROUND SUPPORT	IDENTIFY MALFUNCTIONS	INSPECTION	INSTALL INSTRUMENTS	INVENTORY MATERIALS	LAUNCH OPERATIONS
I. SCIENTIFIC RESEARCH			4	2	3	3		3
II. ENGINEERING AND TECH. OPERATIONS			4	4	3		1	3
III. COMPUTER AND AUTOMATION TECH.			1	4		3		
IV. DEVELOPMENT AND TECHNOLOGY			4		3	3	1	3
V. MONITORING AND SERVICE FUNCTIONS			4	4	3			3
VI. MEDICAL AND BIO. STUDIES			4					
VII. FLIGHT OPERATIONS	4	3	4	4				

1. – Can be Performed Best by Remote Control and Automation
2. – Can be Performed Either by Remote Control or by Man
3. – Can be Performed Best by Man
4. – Can be Performed Best by Interactive Man/Machine System

Figure 2.

FUNCTIONS WHICH CAN BE PERFORMED BY MAN FOR EACH DISCIPLINE AREA AND ALL OF THE INITIATIVES

DISCIPLINE AREA \ FUNCTION PERFORMED	MAINTAIN "HOUSEKEEPING"	MANEUVER SYSTEMS	MANUFACTURE	MEDICAL & HEALTH FUNCTIONS.	MODIFY OPERATION	MONITOR INSTRUMENTS	MONITOR PROCESSES	NAVIGATION	OBSERVE	OPERATE MANIPULATORS	ORBIT CHANGE	ORIENT STRUCTURES	POSITION & RANGE DETERM.	PROCESS MATERIALS	PROPULSION	REBUILD DAMAGED SYSTEM	RECORD DATA	RECOVER PAYLOADS	REENTER	REMOVE SUBSYSTEMS	REPLACE FAILED PARTS	REPLACE SURFACE COATINGS	REPLENISH MATERIALS	RESTORE JAMMED PARTS	REWIRE CIRCUITS	SCHEDULE OPERATIONS	STATIONKEEPING	TEST PROGRAMS	TRANSFER DATA	UNFURL SUBSTRUCTURES	USE MACHINES/TOOLS	WASTE MANAGEMENT
I. SCIENTIFIC RESEARCH					3	2	1		3				1				2				3	4		3	3	3		2	2	4		
II. ENGINEERING AND TECH. OPERATIONS	4	4	4			2				4	4	4	1	2		4				2	4	4	4	3	3		4	4		4	4	2
III. COMPUTER AND AUTOMATION TECH.					1	4	4														3				3	2		1	1			
IV. DEVELOPMENT AND TECHNOLOGY			4		4	2	4		3	4				2			2			4		4		3					2	4	4	4
V. MONITORING AND SERVICE FUNCTIONS	1				1	4	4		4												4	4	4	3	3	1		4	1	4		4
VI. MEDICAL AND BIO. STUDIES				4		2											2															
VII. FLIGHT OPERATIONS	4	4				4		1		4	4	4	1		4		4	4								3	4					4

1. - Can be Performed Best by Remote Control and Automation
2. - Can be Performed Either by Remote Control or by Man
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Figure 3.