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OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C 20301

RESEARCH AND ENGINEERING

DECLASSIFIED IN PART
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 1 1 2016

10 MAR 1983

MEMORANDUM FOR DR. DELAUER

SUBJECT: Warfare in Space (U)

OSD 3.3(b)(1),(4),(5)

(U) Attached are comments on Dr. Mark's paper on "Warfare in Space". These comments are reasonably comprehensive, but because of Hans' stature and interest in being a spokesman on this subject, I think it's worthwhile to go on record with our views.

~~(S)~~ You might want to point out to Hans, the fact that [redacted] ASAT miniature vehicle has a homing capability is now classified [redacted] and while the fact of satellite "photoreconnaissance" for use in monitoring arms control agreements is UNCLASSIFIED, [redacted] fact that the United States conducts satellite reconnaissance for intelligence purposes, without disclosing the generic type of [redacted]

OSD 3.3(b)(1)

T. K. Jones
Deputy Under Secretary
Strategic & Theater
Nuclear Forces

NASA has No Objection to DECLASSIFICATION
Reviewer: 212740
Date: 4/29/2016

Department of Energy Declassification Review
1st Review Date: 3/13/14
Authority: DC DD
Derived From:
Declassify On:
2nd Review Date: 3/18/14
Authority: DD
Determination: (Circle Number(s))
1. Classification Retained
2. Classification Changed To:
3. Contains No DOE Classified Info
4. Coordinate With:
5. Declassified
6. Classified Info Bracketed
7. Other (Specify)

WITH ATTACHMENTS/ENCL

Office of the Secretary of Defense 5 U.S.C. §552
Chief, RDD, ESD, WHS
Date: 11 Jul 2016 Authority: EO 13526
Declassify: ______ Deny in Full: ______
Declassify in Part: x
Reason: 3.3(b)(1),(4),(5)
MDR: 13 -M- 4758

13-M-4758

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR RESEARCH AND ENGINEERING
EXECUTIVE ASSISTANT

Memo for DUSD(SIT&NF) Date 9 Feb 83

Review and prepare response for USDRE signature	X
Respond direct—provide me a copy of your reply	
Review & recommend coord position to USDRE	
Coordinate direct	
Take action as you consider appropriate	
Comment and return	
Information	
See USDRE comments	

REMARKS

10 Feb

Kenneth [illegible]
Lt. Colonel, USA
Executive Assistant
to USDRE

SUSPENSE DATE: NLT
Control # 830379 Dated
From Dr. [illegible] Hans Mark
Subject:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

THE DEPUTY ADMINISTRATOR

USDRE has seen

January 19, 1983

Dear Dick:

Enclosed is a short paper outlining some of my thoughts on "Warfare in Space". I think you might be interested and/or amused.

Best Regards,

Hans.

HANS MARK

3-8-9

Pride

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

RESEARCH AND ENGINEERING

7 February 1983

MEMORANDUM FOR DR. DELAUER

SUBJECT: Warfare in Space

I've read Dr. Mark's paper and concur that he makes a compelling case for protecting by one means or another our capability to use space for military purposes. The paper does raise questions, however:

- If the survivability solution for a "wartime" satellite system is to launch on warning, why should we constrain their design by placing them in Titan silos?

- Having conceded that [redacted] against nuclear attack or against space-based [redacted] and noting that space stations must be defended, how can we advocate space stations?

Do you wish to send a reply raising these questions?

Yes, prepare reply ✓

No ______

T. K. Jones
Deputy Under Secretary
Strategic and Theater Nuclear
Forces

OSD 3.3(b)(1)
NRO 3.3(b)(1)

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THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

RESEARCH AND ENGINEERING

OSD 3.3(b)(1)
NRO 3.3(b)(1)

Dr. Hans Mark
Deputy Administrator
National Aeronautics & Space Administration
Washington, DC 20546

Dear Hans:

I have reviewed your paper on "Warfare in Space" and believe you underscore the compelling cause for the requirement to ensure, by one scheme or another, the availability of our space-based national security systems in view of the increasing Soviet threat. I would note that the historical precedent you offer for the evolution of space warfare can be found not only in aerial systems but in the general pattern of measures and countermeasures in the development of all critical military capabilities -- although perhaps not as directly as in the aerial warfare precedent you cite. In particular, I believe there is an underlying thread of logic: (1) Space systems are critical to national security and are becoming more important to military operations, (2) The threat to our space systems will grow in direct proportion to our dependence on them, and (3) We must, therefore, take appropriate steps to assure the availability and superiority of these critical systems as needed throughout the spectrum of conflict. Further, we must look at the survivability of space assets as a systems problem that demands attention not only to the spacecraft, but to the data stream, the ground stations and processing elements which disseminate the data, and the command/control and launch systems that deploy and control the space segments.

With respect to spacecraft survivability, I believe we must consider a variety of means such as [redacted]

[redacted]

We need to recognize that the same techniques may not be the universally preferred survivability solution for systems with widely differing capabilities, purposes, and orbital placements; the definition of preferred survivability and endurance strategies for a particular mission is a critical task.

For systems at high altitude (geosynchronous), [redacted] appears to have merit and, I believe, reflects current Air Force thinking. The mid-altitudes, where trapped radiation from nuclear explosions which you note is a real threat, fortunately are not widely used for national security space systems. For certain systems, such as GPS, which inherently have a large number of spacecraft, proliferation may be the preferred scheme. And for still others, reconstitution may be a necessity, although reconstitution by replenishment launch has some severe drawbacks. A quick-reaction launch-on-warning system could place the replenishment assets at the same essential risk as the deployed systems, and a survivable launch system would place even more severe constraints on throw weight capability perhaps leading to the very expensive requirement for dual "peacetime" and "wartime" systems which you suggest. Having said all this, reconstitution may still be the best solution for low altitude systems where the major challenges for survivability exist. A necessary first step is a better determination of endurance requirements for each system -- under what conditions, for how long, and with what constraints, and at what cost. After that, we can design the systems and assess costs.

With respect to consideration of a military mission for some future space station, you present what appears to be a contradiction of logic. Having conceded that [redacted] and noting that space stations must be defended, how can we advocate a military space station?

On the subject of organization, I disagree with your view that "eventually, the Space Division should be absorbed into Space Command". While close ties between the user and developer are mandatory, I do not believe subsuming the acquisition role within an operational command is in the best interest of the evolving mission in space. I fully agree with your observation that an essential element for the successful conduct of prospective warfare in space is a military command that has both the responsibility and authority to conduct space-related operations. This responsibility should include the development of strategy and doctrine, the operation of launch vehicles and spacecraft-related to the space command mission, the processing and distribution of data obtained by these spacecraft, and development of new concepts. It should also include the definition of military operational requirements to be fulfilled by space systems. But the development of hardware to satisfy these operational needs is properly the role of an acquisition oriented element. Neither do I believe it would be in our best interest to conduct all space operations by a single command any more than it would be prudent to place all military aviation under a single command. Our view is that space is a place and we should not impose artificial "territorial boundaries" to impede the accomplishment of any command's mission where use of space systems would provide an advantage. The current thrust of all our on-going efforts in this area is to develop space systems, including support structure, which are reliable and efficient and are sufficently survivable in conflict to increase the confidence of our operational commanders in their continued availability and thereby permit them to place greater confidence in their use to support military operations. This course is appropriate as the ultimate mission of the space command evolves.

I hope these personal comments are useful to your thought process on this critical subject. Please recognize that I offer them as considerations rather than definitive conclusions. I appreciate your perspective and welcome continued dialogue on this subject.

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"WARFARE IN SPACE"

I. INTRODUCTION

Ever since the first orbital flight by Russia's Sputnik I in 1957, people have been speculating about what operations in space mean to the conduct of war. As it turns out, there are some good historical precedents that can be used to try and understand what might be expected. The primary functions carried out by national security related satellites today are surveillance, reconnaissance, and communications. The first flying "machines", the lighter-than-air balloons, were used for essentially the same purpose. The hot air balloon was invented by the Montgolfier Brothers in the last years of the 18th Century, and it was not long before they were applied to military operations. Balloons were employed for the same reason that we use satellites today which is that they give the observer a much broader and synoptic view of the field of conflict than anything that can be done from a vantage point on the ground. At the Battle of Fleurus in 1794, the French used balloons for surveillance of the battlefield, and their employment turned out to be decisive with respect to the outcome of the battle. Later, in 1849, balloons were again employed by the Austrians to drop bombs on the city of Venice. During the American Civil War (1860-1865), the Union Army actually had an organized balloon unit which was employed for reconnaissance and artillery spotting. In 1870, balloons were used for similar purposes during the Franco-Prussian

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[redacted]

War. As the range and accuracy of artillery and small arms fire improved, balloons proved to be impractical as airborne observation platforms because they were too vulnerable.

When flight, using heavier-than-air machines, was proved possible by the epoch making experiments of Wilbur and Orville Wright in December 1903, the military applications of the new vehicle quickly became obvious. In February 1908, by which time the Wrights had clearly demonstrated that sustained flight was possible for lengthy periods of time, they signed a contract with the U.S. Army Signal Corps to produce the first military aircraft. It is significant that the Signal Corps was the branch of the service first interested in airplanes since they had the responsibility for providing the information necessary for the commanders on the ground to fight the battle. It was not long before aircraft much like the ones built by the Wrights were used in actual combat situations. The first recorded use of an aircraft during a military operation was in a skirmish between Italian and Turkish troops in North Africa in 1911. The Italians used the aircraft, but the effect it had on the outcome of this incident is not recorded.

In the early months of World War I, both sides used aircraft for reconnaissance purposes much the same way that balloons were used in earlier conflicts. Since the functions performed by the aircraft were valuable, each side quickly developed ways and means for attacking the aircraft of the other and it was not long before air warfare developed pretty much to the point where the air above the battlefield became a separate field of conflict. There were "pursuit" planes which were developed to "pursue" and shoot down the enemy's reconnaissance aircraft. Very rapid strides were made in the technology of large aircraft and, by the end of the first World War, both sides possessed large long range bombers that were capable of reaching each other's population centers. German "Gotha" bombers raided London and the British Handley-Page machines did likewise to cities on the continent of Europe. The youthful Igor Sikorsky, who was later to play the leading role in the development of the helicopter, built what was then the world's largest airplane in 1913 for Czarist Russia. It was called the "Ilya Mourometz" and it set a number of world records, including a non-stop long distance flight from Kiev to Petrograd (now Leningrad) and return--a distance of 1600 miles.

By the end of World War I, all of the significant elements of air power were in place, fighters for air-to-air combat, bombers for the attack of targets on the ground, observation aircraft for reconnaissance, and transport aircraft for movement. Several nations, Great Britain, France, and Germany among others, believed that air warfare was so important that separate military services were established to deal with air combat. Others, such as the United States and Japan, chose to keep their air services attached to the traditional services, the Army and the Navy, and did not set up separate air services until after the end of World War II. During World War II, all of these elements were refined, and the employment of airpower at sea by aircraft carriers was added. However, no really fundamental changes were made in the doctrines and principles of air warfare as they were established during the first world war.

II. SATELLITE SURVEILLANCE

At the conclusion of the second world war, the so-called "cold war" between the United States and Soviet Russia began. Here also, the function of reconnaissance was crucial and both sides have developed very sophisticated technical means for gaining information about what the other is doing. In the early 1950's, the U-2 reconnaissance aircraft was created in an extraordinary technical tour-de-force by Kelly Johnson and his collaborators. For a number of years, these remarkable airplanes flew over "denied" territory with impunity because they could fly at such extremely high altitudes. In those years, they gathered much useful information on which political decision makers came to depend. During the same period, the technology to put man-made satellites in earth orbit was also being vigorously pursued. It happened therefore that when the era of the U-2 was brought to a close in 1960 by the Russian's downing of the airplane flown by Francis Gary Powers, earth orbiting satellites that could perform similar functions were nearly ready to be deployed. The first of these was launched in the early 1960's, and these satellites have played an increasingly important role since that time.

Satellite reconnaissance is of fundamental importance because it reduces the uncertainties that our political leaders must face in making important decisions related to the national security. It is really for this reason that both the Russians and ourselves agreed not to attack each other's "national technical means of verification"--which was the euphemism then employed for photoreconnaissance satellites--in the 1972 Arms Control Agreement (SALT I). (It was only in 1978 that President Carter publicly announced the fact that the United States possessed photoreconnaissance satellites.) It is significant that in spite of this agreement, the Russians were already well along in the development of an anti-satellite system which was designed to shoot down the surveillance satellites of the United States. The Russians made this heavy investment because they recognized that these satellites are much more important to the United States than the equivalent systems are to the Russians. It was a graphic illustration of the problems that an open and free society such as ours has in dealing with a closed, tight fisted tyranny. The Russians have many ways other than earth satellites of gaining information about the United States, but the same is not true for the United States. We rely much more on our satellites than the Russians rely on theirs, and this is why the Russians have already developed and fielded an anti-satellite system that is now operational. With this step, the Russians opened the era of warfare in space, and they did it for much the same reason that the Confederate Army developed the means for shooting down Union balloons. The United States satellites perform a very valuable function and the Russians know this and they therefore wish to have the capability to deny us these functions. The pattern that was established in the development of aerial warfare has therefore been followed--so far at least--in the case of space warfare as well.

III. ANTI-SATELLITE SYSTEMS

The Russian anti-satellite system--which was tested successfully for the first time in [1972]--is a relatively primitive device technically but it has nevertheless proved to be effective in a number of tests. The Russian anti-satellite system depends on [redacted]

[redacted] Since weight is always at a premium on spacecraft, this price may often be very high indeed. It is for this reason that making satellites survivable is a very difficult business because the usual engineering trade-off between offensive and defensive capability--such as between guns, armor, and speed on a warship--becomes very much more complicated.

OSD 3.3(b)(1)

There is every reason to believe that new methods of destroying orbiting satellites will be developed in the coming years that [redacted] The United States is now working on an anti-satellite system based on the technology [redacted] These vehicles would be launched using small but very powerful solid fuel rockets carried on fighter aircraft such as the F-15. [redacted]

OSD 3.3(b)(1)(a)(1)(h)(5)

[redacted] It is, of course, the closing speed problem that presents the largest technical difficulty in the development and design of space based weapons. Unlike conventional aircraft which need to move with speeds of only a few hundred miles an hour to sustain forward flight, a spacecraft must have a velocity of 17,000 miles per hour in order to sustain itself in earth orbit. It can easily be seen therefore that unless an attacking spacecraft is in nearly the same orbit as the target (that is it co-orbits with the target) very high relative velocities will be encountered. These high relative velocities mean, in turn, that a formidable fire control problem must be solved. It is this consideration that has led many people to speculate on the possibility that lasers might eventually be the best weapons for the conduct of warfare in space in which the primary objective is to destroy the enemy's satellites. Lasers have the great advantage that the energy used to destroy the target travels with the speed of light--which is always very large compared to the speed of the target in any practical situation. Therefore, the normal "lead" calculation in the fire control problem is greatly simplified compared to the case where the destructive energy is carried by a projectile that travels with a speed comparable to that of the target.

IV. LASERS

Although the principle on which lasers are based, the stimulated emission of electromagnetic radiation, was discovered in 1917 by Albert Einstein, the first successful laser was not produced until 1962 by T. H. Maiman and his collaborators. In addition to understanding the principle, means had to be developed for applying in practice what Einstein had discovered in theory. The essential problem of the laser was then, and is still, that it is not very efficient. This means that not much of the energy used to produce the laser beam actually winds up in the beam in such a way that it is capable of doing damage of military interest. Operational gas dynamic lasers today have efficiencies of the order of five percent--that is--five percent of the energy required to produce the laser beam actually goes into the beam. Although beams having fairly high energies--of the order of several hundred kilowatts to perhaps one megawatt--have been produced, the lasers capable of doing this require large and complex installations. There are some very promising concepts--especially in the area of chemical lasers and free electron devices--which would have much higher efficiencies than currently available gas dynamic or chemical lasers. Thus, there is good reason to believe that much more progress can be made by doing the necessary research and development in this field.

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NRO 3.3(b)(1)

In spite of these difficulties, very significant progress has been made since 1962 in the creation of lasers that have the capacity to do damage that might be of military interest. We have developed lasers that have destroyed ~~air-to-air~~ small guided missiles in flight in an experimental setting. We have also put a large laser on a large transport-type airplane--the Airborne Laser Laboratory--which is intended to demonstrate the ability of lasers to destroy missiles of various types from airplanes. In conducting experiments with the Airborne Laser Laboratory, we have learned much about the fire control problem and also the technology of packaging lasers to minimize weight and size. Both of these areas will be important when the time comes to place high energy lasers in space.

Even though it is difficult to produce lasers [redacted] doing damage of military interest to "normal" [redacted]

[redacted]

V. SURVIVABILITY

What can be done to protect orbiting satellites and launch vehicles such as the Shuttle against the near-term threats that have been described? Considering the value of reconnaissance and surveillance satellites, succeeding administrations in this country have expressed continuing concern over the problem of satellite vulnerability. Actually doing something concrete, however, turns out to be distasteful and expensive because of the very stringent weight constraints under which satellite systems are designed. Meaningful defensive measures almost always compromise the capability of the satellite to perform its primary mission beyond the point that has been considered profitable. It is probable, nevertheless, that satellites can be built that can deal somehow with the near-term threats. The possibility of [redacted]

[redacted]

Nothing has been said so far about the employment of nuclear explosives to bring down satellites. Nuclear explosives detonated in the earth's magnetosphere produce large numbers of high energy charged particles (electrons and protons as well as heavier ions) that are trapped into relatively stable orbits around the earth by the earth's magnetic field. These particles can seriously damage many kinds of satellites when the satellites are exposed to the particles above the atmosphere. Since these energetic particles quickly spread around the entire globe, it does not matter very much where the original nuclear explosion occurred.

[redacted]

OSD 3.3(b)(1) NRO 3.3(b)(1)

[redacted]

Having said all this, we are still left with the problem of developing the technical means for protecting satellite systems and, probably more important, evolving the military doctrines that govern what should be done. In the case of satellite vulnerability, it is very probable that the correct answer will be to actually develop two sets of military satellite systems, one designed for "peacetime" applications and the other to be fielded only after a high level of hostilities is reached. The "peacetime" system would be designed so as to maximize the capability to provide warning, intelligence, and communications until such time as the decision to employ nuclear weapons is reached. Clearly, the value of information up to that point is extremely critical and therefore the capability to secure this information should not be compromised. Once a nuclear conflict starts, then the requirement for information changes drastically and there is good reason to believe that new requirements for information following a nuclear exchange could be fulfilled by a "wartime" satellite system that is less capable but that is also less vulnerable to destruction than the "peacetime" system. Very probably the right way to fulfill the objectives just outlined is to keep the satellites of the hardened "wartime" system on the ground and then launch them using a launch system designed to survive an initial nuclear exchange.

The existence of the MX missile offers us the opportunity to develop a "wartime" satellite system that could fulfill many of the information requirements that political and military leaders would have during a nuclear conflict. The MX missile is a capable space launch vehicle that can place about 5500 pounds of payload in a near earth 30^{o} inclination orbit and somewhat less--perhaps 4000 pounds in a polar orbit. The technology exists today to build reasonable and hardened payloads in this weight class for photography and various purposes associated with the gathering of electronic intelligence. It is also possible to develop a manned "space plane" in this weight category which would be used for surveillance if all ground receiving stations and the relay communications systems used by them became inoperable. (Remember that the "Mercury" spacecraft weighed only 3600 pounds and that with current technology it should be relatively easy to build a space plane capable of going into orbit and then returning in much the same manner as the Space Shuttle does today.) Once a set of payloads of this kind is available, they would be placed on top of MX missiles and deployed in standard ICBM silos. (Since the Titan II system is now being dismantled, it has been suggested that the 54 Titan II silos might be employed for this purpose.) The MX missiles are designed to remain in standby conditions for long periods of time and it should pose no real problems to design the payloads so that they can be kept in a ready to launch posture for long periods as well. The employment doctrine of this system could vary with the precise situation but one contingency is clearly a surprise first strike nuclear attack on the Continental United States. In this case, the MX missiles carrying the reconnaissance payloads would be launched on warning of the attack--that is--when the "peacetime" sensors say the attack is on the way. The "wartime" satellite surveillance system launched using the MX missiles would then be in place to assess the damage done by the exchange on both sides. Another scenario would be to declare an attack on the "peacetime" systems an act of war and to launch the "wartime" satellites with a strike that would retaliate against the destruction of the peacetime systems. These are only two examples of how the "wartime" system might be employed and it is obvious that there are many more.

VI. SPACE STATIONS

Everything that has been said so far deals with the relatively near-term future--that is--the next decade or so. In the longer term, it is almost certain that both the Russians and the United States will develop manned orbiting space stations for various purposes. Ultimately, these will also have to be defended and in the two or three decades that it will take to develop these space stations it is likely that space based laser weapons will become technically feasible. It is not possible to predict with any degree of certainty just what these stations will be used for, but it is likely that some of the functions will be of sufficient value and that therefore the stations will have to defend themselves just the way military aircraft must defend themselves today. It is most likely that some of these stations will become space based command posts to operate the defense systems against ICBM and SLBM attacks that might be built during the same period. There is every reason to believe that the technology to field such defensive systems will become available and that this must be considered in the new strategic equation. The very accurate guidance and control technology [redacted] can also be employed to bring down reentry vehicles carried by ICBM's and SLBM's. The

OSD 3.3(b)(1),(4),(5)

technical problem turns out to be slightly more difficult but still manageable. In addition to this possibility, there is the suggestion that large space based lasers could be employed to shoot down ICBM's and SLBM's during their launch phases when they are easy to detect and when the relatively "soft" booster vehicles can be the primary targets rather than the very "hard" reentry vehicles. This is clearly an even more difficult proposition but since the lasers are likely to become available, it is not too early to think about how they can be effectively deployed. There are some who believe that the application of the technologies just outlined will have a really profound effect on world stability because it will change the doctrine of "mutually assured destruction" which is the intellectual framework for the employment of our current nuclear strategic forces. Once it becomes possible to really defend the launch sites of ICBM's and SLBM's with a high degree of certainty, then clearly new doctrines must be evolved and new concepts of "stability" must be thought through. Although it is not possible to foresee the future, it is very likely that new doctrines will have to be developed and there is at least some hope that these will lead to a world less beset by fear of nuclear war than it is today.

VII. ORGANIZATION

Before closing, it might be a good idea to say a few words about organization. The development of the airplane and its application to warfare eventually led to the creation of a separate military service to deal with the conduct of combat in the air and with other air operations. Will this pattern be followed in space and will it become necessary to establish a separate military service charged with the responsibility of conducting warfare in space? It is obviously too early to answer this question, but it is clear that some organizational steps do need to be taken to deal with the contingencies that can already be foreseen. In October 1982, the U.S. Air Force, recognizing its executive responsibility for military space operations, established the Air Force Space Command. This organization is closely related to the Aerospace Defense Command since the Space Command will be the operational unit that deploys and operates the satellite systems on which the Aerospace Defense Command depends for its primary information regarding strategic warning. The Space Command is located at the same headquarters as the Aerospace Defense Command in Colorado Springs, Colorado, and the two commands are headed by the same four star Air Force general.

In space operations, it is extremely important to make certain that the organization that develops the space hardware has very close ties with the operational unit. The reason for this is that unlike other military hardware systems, space satellites are always fielded only in small numbers and are never really "standardized". Therefore, the distinction between "developmental" and "operational" systems is impossible to draw for space satellites whereas for airplanes and other military hardware fielded in great numbers such a line can be well defined. There is, for example, also no real line on the civilian side between "developmental" and "operational" systems. In NASA, the same organizations develop and then operate systems such as planetary exploration spacecraft and earth orbiting astronomical observatories. This point was recognized when the Space Command was established and the Air Force Lieutenant General commanding the Spac Division of the Air Force Systems Command (the Air Force's developmental organization) was given the additional responsibility of being Vice-Commander of the new Space Command. In this way, some coordination between the Air Force's development organization (Systems Command) and the operational organization (Space Command) can be maintained. Eventually, the Space Division should be absorbed into the Space Command, but there is enough time to take this step in such a manner that it does not cause undue disruption.

What is necessary for the successful conduct of warfare in space is that the United States have a military command that has both the responsibility and the authority to conduct all the operations in space related to national security. This responsibilit starts with the development of strategy and doctrine, continues with the operation on orbit of the satellites and their launch vehicles as well, goes on to the processing and distribution of the data obtained by the satellites, and ends with the development of new concepts and systems hardware to fulfill new military requirements as they arise. Only by the development of the appropriate organization now will the United States be able to continue to conduct those operations in space that are vital to our national security.

Washington, D.C.
January 1983

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

THE DEPUTY ADMINISTRATOR

January 19, 1983

Dear Dick:

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Best Regards,

Hans.

HANS MARK

2-8-9

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OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

RESEARCH AND ENGINEERING

7 February 1983

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Do you wish to send a reply raising these questions?

Yes, prepare reply

No ______

T. K. Jones
Deputy Under Secretary
Strategic and Theater Nuclear Forces

OSD 3.3(b)(1)
NRO 3.3(b)(1)

DECLASSIFIED IN PART
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 1 1 2016

"WARFARE IN SPACE"

I. INTRODUCTION

Ever since the first orbital flight by Russia's Sputnik I in 1957, people have been speculating about what operations in space mean to the conduct of war. As it turns out, there are some good historical precedents that can be used to try and understand what might be expected. The primary functions carried out by national security related satellites today are surveillance, reconnaissance, and communications. The first flying "machines", the lighter-than-air balloons, were used for essentially the same purpose. The hot air balloon was invented by the Montgolfier Brothers in the last years of the 18th Century, and it was not long before they were applied to military operations. Balloons were employed for the same reason that we use satellites today which is that they give the observer a much broader and synoptic view of the field of conflict than anything that can be done from a vantage point on the ground. At the Battle of Fleurus in 1794, the French used balloons for surveillance of the battlefield, and their employment turned out to be decisive with respect to the outcome of the battle. Later, in 1849, balloons were again employed by the Austrians to drop bombs on the city of Venice. During the American Civil War (1860-1865), the Union Army actually had an organized balloon unit which was employed for reconnaissance and artillery spotting. In 1870, balloons were used for similar purposes during the Franco-Prussian

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War. As the range and accuracy of artillery and small arms fire improved, balloons proved to be impractical as airborne observation platforms because they were too vulnerable.

When flight, using heavier-than-air machines, was proved possible by the epoch making experiments of Wilbur and Orville Wright in December 1903, the military applications of the new vehicle quickly became obvious. In February 1908, by which time the Wrights had clearly demonstrated that sustained flight was possible for lengthy periods of time, they signed a contract with the U.S. Army Signal Corps to produce the first military aircraft. It is significant that the Signal Corps was the branch of the service first interested in airplanes since they had the responsibility for providing the information necessary for the commanders on the ground to fight the battle. It was not long before aircraft much like the ones built by the Wrights were used in actual combat situations. The first recorded use of an aircraft during a military operation was in a skirmish between Italian and Turkish troops in North Africa in 1911. The Italians used the aircraft, but the effect it had on the outcome of this incident is not recorded.

In the early months of World War I, both sides used aircraft for reconnaissance purposes much the same way that balloons were used in earlier conflicts. Since the functions performed by the aircraft were valuable, each side quickly developed ways and means for attacking the aircraft of the other and it was not long before air warfare developed pretty much to the point where the air above the battlefield became a separate field of conflict. There were "pursuit" planes which were developed to "pursue" and shoot down the enemy's reconnaissance aircraft. Very rapid strides were made in the technology of large aircraft and, by the end of the first World War, both sides possessed large long range bombers that were capable of reaching each other's population centers. German "Gotha" bombers raided London and the British Handley-Page machines did likewise to cities on the continent of Europe. The youthful Igor Sikorsky, who was later to play the leading role in the development of the helicopter, built what was then the world's largest airplane in 1913 for Czarist Russia. It was called the "Ilya Mourometz" and it set a number of world records, including a non-stop long distance flight from Kiev to Petrograd (now Leningrad) and return--a distance of 1600 miles.

By the end of World War I, all of the significant elements of air power were in place, fighters for air-to-air combat, bombers for the attack of targets on the ground, observation aircraft for reconnaissance, and transport aircraft for movement. Several nations, Great Britain, France, and Germany among others, believed that air warfare was so important that separate military services were established to deal with air combat. Others, such as the United States and Japan, chose to keep their air services attached to the traditional services, the Army and the Navy, and did not set up separate air services until after the end of World War II. During World War II, all of these elements were refined, and the employment of airpower at sea by aircraft carriers was added. However, no really fundamental changes were made in the doctrines and principles of air warfare as they were established during the first world war.

II. SATELLITE SURVEILLANCE

At the conclusion of the second world war, the so-called "cold war" between the United States and Soviet Russia began. Here also, the function of reconnaissance was crucial and both sides have developed very sophisticated technical means for gaining information about what the other is doing. In the early 1950's, the U-2 reconnaissance aircraft was created in an extraordinary technical tour-de-force by Kelly Johnson and his collaborators. For a number of years, these remarkable airplanes flew over "denied" territory with impunity because they could fly at such extremely high altitudes. In those years, they gathered much useful information on which political decision makers came to depend. During the same period, the technology to put man-made satellites in earth orbit was also being vigorously pursued. It happened therefore that when the era of the U-2 was brought to a close in 1960 by the Russian's downing of the airplane flown by Francis Gary Powers, earth orbiting satellites that could perform similar functions were nearly ready to be deployed. The first of these was launched in the early 1960's, and these satellites have played an increasingly important role since that time.

Satellite reconnaissance is of fundamental importance because it reduces the uncertainties that our political leaders must face in making important decisions related to the national security. It is really for this reason that both the Russians and ourselves agreed not to attack each other's "national technical means of verification"--which was the euphemism then employed for photoreconnaissance satellites--in the 1972 Arms Control Agreement (SALT I). (It was only in 1978 that President Carter publicly announced the fact that the United States possessed photoreconnaissance satellites.) It is significant that in spite of this agreement, the Russians were already well along in the development of an anti-satellite system which was designed to shoot down the surveillance satellites of the United States. The Russians made this heavy investment because they recognized that these satellites are much more important to the United States than the equivalent systems are to the Russians. It was a graphic illustration of the problems that an open and free society such as ours has in dealing with a closed, tight fisted tyranny. The Russians have many ways other than earth satellites of gaining information about the United States, but the same is not true for the United States. We rely much more on our satellites than the Russians rely on theirs, and this is why the Russians have already developed and fielded an anti-satellite system that is now operational. With this step, the Russians opened the era of warfare in space, and they did it for much the same reason that the Confederate Army developed the means for shooting down Union balloons. The United States satellites perform a very valuable function and the Russians know this and they therefore wish to have the capability to deny us these functions. The pattern that was established in the development of aerial warfare has therefore been followed--so far at least--in the case of space warfare as well.

III. ANTI-SATELLITE SYSTEMS

The Russian anti-satellite system--which was tested successfully for the first time in [1972]--is a relatively primitive device technically but it has nevertheless proved to be effective in a number of tests. The Russian anti-satellite system depends on [redacted]

OSD 3.3(b)(1) NRO 3.3(b)(1)

[redacted] Since weight is always at a premium on spacecraft, this price may often be very high indeed. It is for this reason that making satellites survivable is a very difficult business because the usual engineering trade-off between offensive and defensive capability--such as between guns, armor, and speed on a warship--becomes very much more complicated. OSD 3.3(b)(1) NRO 3.3(b)(1)

There is every reason to believe that new methods of destroying orbiting satellites will be developed in the coming years that [redacted] The United States is now working on an anti-satellite system based on the technology [redacted] These vehicles would be launched using small but very powerful solid fuel rockets carried on fighter aircraft such as the F-15. [redacted]

[redacted] It is, of course, the closing speed problem that presents the largest technical difficulty in the development and design of space based weapons. Unlike conventional aircraft which need to move with speeds of only a few hundred miles an hour to sustain forward flight, a spacecraft must have a velocity of 17,000 miles per hour in order to sustain itself in earth orbit. It can easily be seen therefore that unless an attacking spacecraft is in nearly the same orbit as the target (that is it co-orbits with the target) very high relative velocities will be encountered. These high relative velocities mean, in turn, that a formidable fire control problem must be solved. It is this consideration that has led many people to speculate on the possibility that lasers might eventually be the best weapons for the conduct of warfare in space in which the primary objective is to destroy the enemy's satellites. Lasers have the great advantage that the energy used to destroy the target travels with the speed of light--which is always very large compared to the speed of the target in any practical situation. Therefore, the normal "lead" calculation in the fire control problem is greatly simplified compared to the case where the destructive energy is carried by a projectile that travels with a speed comparable to that of the target.

OSD 3.3(b)(1),(4),(5)

IV. LASERS

Although the principle on which lasers are based, the stimulated emission of electromagnetic radiation, was discovered in 1917 by Albert Einstein, the first successful laser was not produced until 1962 by T. H. Maiman and his collaborators. In addition to understanding the principle, means had to be developed for applying in practice what Einstein had discovered in theory. The essential problem of the laser was then, and is still, that it is not very efficient. This means that not much of the energy used to produce the laser beam actually winds up in the beam in such a way that it is capable of doing damage of military interest. Operational gas dynamic lasers today have efficiencies of the order of five percent--that is--five percent of the energy required to produce the laser beam actually goes into the beam. Although beams having fairly high energies--of the order of several hundred kilowatts to perhaps one megawatt--have been produced, the lasers capable of doing this require large and complex installations. There are some very promising concepts--especially in the area of chemical lasers and free electron devices--which would have much higher efficiencies than currently available gas dynamic or chemical lasers. Thus, there is good reason to believe that much more progress can be made by doing the necessary research and development in this field.

In spite of these difficulties, very significant progress has been made since 1962 in the creation of lasers that have the capacity to do damage that might be of military interest. We have developed lasers that have destroyed ~~air-to-air~~ small guided missiles in flight in an experimental setting. We have also put a large laser on a large transport-type airplane--the Airborne Laser Laboratory--which is intended to demonstrate the ability of lasers to destroy missiles of various types from airplanes. In conducting experiments with the Airborne Laser Laboratory, we have learned much about the fire control problem and also the technology of packaging lasers to minimize weight and size. Both of these areas will be important when the time comes to place high energy lasers in space.

Even though it is difficult to produce lasers capable of doing damage of military interest to "normal" targets, [redacted]

OSD 3.3(b)(1) NRO 3.3 (b)(1)

[redacted]

V. SURVIVABILITY

What can be done to protect orbiting satellites and launch vehicles such as the Shuttle against the near-term threats that have been described? Considering the value of reconnaissance and surveillance satellites, succeeding administrations in this country have expressed continuing concern over the problem of satellite vulnerability. Actually doing something concrete, however, turns out to be distasteful and expensive because of the very stringent weight constraints under which satellite systems are designed. Meaningful defensive measures almost always compromise the capability of the satellite to perform its primary mission beyond the point that has been considered profitable. It is probable, nevertheless, that satellites can be built that can deal somehow with the near-term threats. The possibility of [redacted]

[redacted]

Nothing has been said so far about the employment of nuclear explosives to bring down satellites. Nuclear explosives detonated in the earth's magnetosphere produce large numbers of high energy charged particles (electrons and protons as well as heavier ions) that are trapped into relatively stable orbits around the earth by the earth's magnetic field. These particles can seriously damage many kinds of satellites when the satellites are exposed to the particles above the atmosphere. Since these energetic particles quickly spread around the entire globe, it does not matter very much where the original nuclear explosion occurred.

[redacted]

OSD 3.3(b)(1) NRO 3.3(b)(1) ~~SECRET~~

[redacted]

Having said all this, we are still left with the problem of developing the technical means for protecting satellite systems and, probably more important, evolving the military doctrines that govern what should be done. In the case of satellite vulnerability, it is very probable that the correct answer will be to actually develop two sets of military satellite systems, one designed for "peacetime" applications and the other to be fielded only after a high level of hostilities is reached. The "peacetime" system would be designed so as to maximize the capability to provide warning, intelligence, and communications until such time as the decision to employ nuclear weapons is reached. Clearly, the value of information up to that point is extremely critical and therefore the capability to secure this information should not be compromised. Once a nuclear conflict starts, then the requirement for information changes drastically and there is good reason to believe that new requirements for information following a nuclear exchange could be fulfilled by a "wartime" satellite system that is less capable but that is also less vulnerable to destruction than the "peacetime" system. Very probably the right way to fulfill the objectives just outlined is to keep the satellites of the hardened "wartime" system on the ground and then launch them using a launch system designed to survive an initial nuclear exchange.

The existence of the MX missile offers us the opportunity to develop a "wartime" satellite system that could fulfill many of the information requirements that political and military leaders would have during a nuclear conflict. The MX missile is a capable space launch vehicle that can place about 5500 pounds of payload in a near earth 30^{o} inclination orbit and somewhat less--perhaps 4000 pounds in a polar orbit. The technology exists today to build reasonable and hardened payloads in this weight class for photography and various purposes associated with the gathering of electronic intelligence. It is also possible to develop a manned "space plane" in this weight category which would be used for surveillance if all ground receiving stations and the relay communications systems used by them became inoperable. (Remember that the "Mercury" spacecraft weighed only 3600 pounds and that with current technology it should be relatively easy to build a space plane capable of going into orbit and then returning in much the same manner as the Space Shuttle does today.) Once a set of payloads of this kind is available, they would be placed on top of MX missiles and deployed in standard ICBM silos. (Since the Titan II system is now being dismantled, it has been suggested that the 54 Titan II silos might be employed for this purpose.) The MX missiles are designed to remain in standby conditions for long periods of time and it should pose no real problems to design the payloads so that they can be kept in a ready to launch posture for long periods as well. The employment doctrine of this system could vary with the precise situation but one contingency is clearly a surprise first strike nuclear attack on the Continental United States. In this case, the MX missiles carrying the reconnaissance payloads would be launched on warning of the attack--that is--when the "peacetime" sensors say the attack is on the way. The "wartime" satellite surveillance system launched using the MX missiles would then be in place to assess the damage done by the exchange on both sides. Another scenario would be to declare an attack on the "peacetime" systems an act of war and to launch the "wartime" satellites with a strike that would retaliate against the destruction of the peacetime systems. These are only two examples of how the "wartime" system might be employed and it is obvious that there are many more.

VI. SPACE STATIONS

Everything that has been said so far deals with the relatively near-term future--that is--the next decade or so. In the longer term, it is almost certain that both the Russians and the United States will develop manned orbiting space stations for various purposes. Ultimately, these will also have to be defended and in the two or three decades that it will take to develop these space stations it is likely that space based laser weapons will become technically feasible. It is not possible to predict with any degree of certainty just what these stations will be used for, but it is likely that some of the functions will be of sufficient value and that therefore the stations will have to defend themselves just the way military aircraft must defend themselves today. It is most likely that some of these stations will become space based command posts to operate the defense systems against ICBM and SLBM attacks that might be built during the same period. There is every reason to believe that the technology to field such defensive systems will become available and that this must be considered in the new strategic equation. The very accurate guidance and control technology [redacted] can also be employed to bring down reentry vehicles carried by ICBM's and SLBM's. The technical problem turns out to be slightly more difficult but still manageable. In addition to this possibility, there is the suggestion that large space based lasers could be employed to shoot down ICBM's and SLBM's during their launch phases when they are easy to detect and when the relatively "soft" booster vehicles can be the primary targets rather than the very "hard" reentry vehicles. This is clearly an even more difficult proposition but since the lasers are likely to become available, it is not too early to think about how they can be effectively deployed. There are some who believe that the application of the technologies just outlined will have a really profound effect on world stability because it will change the doctrine of "mutually assured destruction" which is the intellectual framework for the employment of our current nuclear strategic forces. Once it becomes possible to really defend the launch sites of ICBM's and SLBM's with a high degree of certainty, then clearly new doctrines must be evolved and new concepts of "stability" must be thought through. Although it is not possible to foresee the future, it is very likely that new doctrines will have to be developed and there is at least some hope that these will lead to a world less beset by fear of nuclear war than it is today.

VII. ORGANIZATION

Before closing, it might be a good idea to say a few words about organization. The development of the airplane and its application to warfare eventually led to the creation of a separate military service to deal with the conduct of combat in the air and with other air operations. Will this pattern be followed in space and will it become necessary to establish a separate military service charged with the responsibility of conducting warfare in space? It is obviously too early to answer this question, but it is clear that some organizational steps do need to be taken to deal with the contingencies that can already be foreseen. In October 1982, the U.S. Air Force, recognizing its executive responsibility for military space operations, established the Air Force Space Command. This organization is closely related to the Aerospace Defense Command since the Space Command will be the operational unit that deploys and operates the satellite systems on which the Aerospace Defense Command depends for its primary information regarding strategic warning. The Space Command is located at the same headquarters as the Aerospace Defense Command in Colorado Springs, Colorado, and the two commands are headed by the same four star Air Force general.

In space operations, it is extremely important to make certain that the organization that develops the space hardware has very close ties with the operational unit. The reason for this is that unlike other military hardware systems, space satellites are always fielded only in small numbers and are never really "standardized". Therefore, the distinction between "developmental" and "operational" systems is impossible to draw for space satellites whereas for airplanes and other military hardware fielded in great numbers such a line can be well defined. There is, for example, also no real line on the civilian side between "developmental" and "operational" systems. In NASA, the same organizations develop and then operate systems such as planetary exploration spacecraft and earth orbiting astronomical observatories. This point was recognized when the Space Command was established and the Air Force Lieutenant General commanding the Space Division of the Air Force Systems Command (the Air Force's developmental organization) was given the additional responsibility of being Vice-Commander of the new Space Command. In this way, some coordination between the Air Force's development organization (Systems Command) and the operational organization (Space Command) can be maintained. Eventually, the Space Division should be absorbed into the Space Command, but there is enough time to take this step in such a manner that it does not cause undue disruption.

What is necessary for the successful conduct of warfare in space is that the United States have a military command that has both the responsibility and the authority to conduct all the operations in space related to national security. This responsibility starts with the development of strategy and doctrine, continues with the operation on orbit of the satellites and their launch vehicles as well, goes on to the processing and distribution of the data obtained by the satellites, and ends with the development of new concepts and systems hardware to fulfill new military requirements as they arise. Only by the development of the appropriate organization now will the United States be able to continue to conduct those operations in space that are vital to our national security.

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