1983

The technical, legal and political implications of remote sensing satellites

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THE TECHNICAL, LEGAL, AND POLITICAL IMPLICATIONS OF REMOTE SENSING SATELLITES

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THESIS

Submitted in partial Fulfillment of the requirements

for the

MASTER OF ARTS DEGREE

Department of Political Science

Wilfrid Laurier University

1983

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ABSTRACT

This thesis examines the phenomenon of reconnaissance satellites and their role in the present arms race. While volumes of material have been written on the arms race in general, or the weapons race in particular, very little has been written on the role of satellites in this conflict and almost nothing has been written on the role of reconnaissance satellites. There is a need for much greater debate on the role of reconnaissance satellites in outer space. Reconnaissance satellites have, in part, rewritten the meaning of the arms race and they have contributed significantly to arms reductions talks between the two superpowers. This thesis examines reconnaissance satellites in both an historical and a modern context. Their legal status is examined. The political and military implications of reconnaissance satellites is discussed as well. In sum, this paper is a pioneering effort. It will explore a little-known topic in the hope that it will stimulate further discussion.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my thesis supervising committee: Professor Nicolas Nyiri as the principal supervisor of my thesis, and Drs. John Redekop and Toivo Miljan for their careful reading of the text. I would also like to thank Mrs. Bonnie Thompson who assisted me in the typing of my thesis.

Introduction

What is the nature of the arms race in space? What kind of a role will satellites play in the ongoing struggle for superiority between the United States and the Soviet Union? And how can Canada influence the world in the exploration and exploitation of the "last frontier"? Questions such as these are basic in any academic venture into the world of remote sensing. The answers, however, are anything but simple. The new technology in space utilization is in some ways only in its infancy but this technology far exceeds the laws that were intended to keep it in check. Mankind is, in essence, developing a technology which will drastically alter the way he lives and thinks yet he is far from understanding the use, or preventing the abuse of remote sensing satellites in his world.

This paper seeks to provide some perspectives on the use of artificial satellites and especially remote sensing satellites and how they are re-shaping the arms race. The emphasis of this paper will concern Canada's role in the development and placement of remote sensing satellites and its political and social implications. There have been no thesis written by political scientists which examine the many implications of remote sensing satellites for Canada. This is understandable perhaps as this field is relatively new. But the important role that this phenomenon will play in the future for Canada alone, not to mention the rest of the world, means that it is now time for social science scholars to catch up with a science that started over two decades ago.

Much of the existing literature in the field of artificial satellites and remote sensing satellites in particular, is devoted to the technology that surrounds them and, therefore, leaves little room for discussion of the social or even military implications of their development. Space law, too, has spent some time debating the legal significance of artificial satellites. There is a wide body of literature on the legal questions concerning the placement of artificial satellites in outer space. For instance, some lawyers argue that outer space does not start until an area of about 35,000 kilometers from the earth's surface while others maintain that it starts as near as eighty kilometers from the surface of the earth. A wide body of legal opinion prefers to choose areas between these two extremes.

However, the most pressing problem regarding the placing of satellites (especially remote sensors) in space is political. Remote sensors are not only instruments of scientific exploration but of government policy as well. As mistrust of an enemy increases, so does the need for verification of that enemy's activities. The United States has used both direct and indirect means of determining that Russia has not been living up to the terms of the SALT I (Strategic Arms Limitations Treaty) agreement.

Photoreconnaissance revealed the presence of new missile sites while infrared techniques verified the presence of missiles that should have been dismantled. Such discoveries significantly altered and no doubt lengthened the course of negotiations in the SALT II talks.

The decisions to develop artificial satellites came firstly during the Cold War but the need to vastly increase the research into remote sensors was mainly a product of the continuing arms race. The present Cold War mentality has provided the Soviets and the Americans with reasons to increase the defense budgets for new weapons, extra manpower and effective means of verification.

Canada will be examined in light of the arms race today and especially in the context of her contribution to the area of remote sensing. Canada is a permanent and respected member of NATO (although her influence is rather small). Canada is also respected in international circles and she has a reputation for being a mediator in international disputes. But Canada is a member of NORAD and the United States is Canada's principal trading partner. Strategically, Canada is essential to the security of the continental United States, providing advanced radar warning and military bases which provide counterstrike capabilities. More central to this thesis, however, is the fact that Canada is one of the most technologically advanced countries in the world and her technology will contribute to the development of the remote sensing satellites that America is now using against Russia. This will strengthen her commitment to NATO but it will increase her dependence on the United

States for defense and, more importantly, it will decrease her credibility as a "strong neutralist power" in international circles.

There is no doubt that Canada has the capability to produce remote sensing satellites. It was the second country to place a domestic telecommunications satellite in space (the first was Russia and the third was the U.S.[1]). Canada presently uses remote sensing satellites for land survey, weather diagnosis, and the like. The central questions for Canada will be: is she prepared to take advantage of the Defense Production Sharing Agreement and produce remote sensing components and risk weakening her credibility in international circles as a quasi-neutralist state? secondly, what position should Canada assume concerning the technical, legal, and political problems that will arise as a result of this new technology?

This thesis will examine the past, present, and future for remote sensing satellites. It will examine the technical, legal, and political ramifications of this technology, the increasing sophistication of the weapons, the developments in laser technology, and the possibility of equipping these instruments with nuclear warheads in the future. The last frontier may present man with the greatest challenge.

The structure of this thesis will now be explained. The first chapter will examine remote sensing in history. It will detail the terms, theories and processes that are the language of remote sensing.

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[1]Steve Durst, "Canada In Space," Space Age Review, August-September 1979, p.188.

It will examine how satellites are placed in orbit and how they behave in orbit. This first chapter might better pass as an essay in physics but without a technical description of how satellites function, a more thorough political discussion would be almost impossible.

The second chapter examines the legal questions surrounding man's use of outer space. This chapter deals with the problems that have occurred and are expected to occur regarding man's use of outer space. Diplomats and lawyers will soon have to devise laws that will address the complex problem of remote sensing.

The third and final chapter will examine the huge political and legal ramifications of remote sensing. The chapter will be divided into two main parts. The first part will examine the international conflicts and tensions in the military arms buildup and how remote sensors are both contributing to and helping to ease the tensions in this conflict. It will examine how satellites may be used as weapons in the future. The second section will highlight some scenarios that might occur because of the presence of remote sensors. These perspectives will be examined in terms of game theory. Canada's role in this international conflict will also be examined. The second section will highlight some scenarios that might occur because of the presence of remote sensors. The conclusions will simply serve to sum up the main points that this thesis will make and will leave the reader with some questions that he might wish to ponder for the future.

CHAPTER I

A TECHNICAL EXAMINATION OF REMOTE SENSORS

From a military analyst's perspective, the advantages of airborne remote sensing techniques over traditional photographic methods can hardly be overestimated. Much of the information that is required by analysts could not be achieved by the use of conventional cameras and photographic techniques. The traditional camera, even with an excellent photographing ability, can not peer inside a building or detect an underground nuclear explosion or nuclear installation. Traditional photography could not identify jets that are in a combat ready position (i.e. their engines turned on). It would be inoperative at night time and could not peer through clouds. These cameras could not identify soil types, small fires, or locate schools of fish. To the military analyst, traditional photography would be of limited use. The need for verification of an enemy's missile installations and nocturnal troop movement can only be accomplished by instruments which utilize the invisible portion of the electromagnetic spectrum. To this end, the military analyst has had to employ some of the most advanced techniques of physics that could be used. The task is to obtain information that will be vital to the security interests of the state that is being spied upon and that will give the spying state information that is vital to its own security interests as well.

Satellite reconnaissance is both a weapon of war and a weapon of peace. It can be used to bring honesty to the bargaining table at an arms reduction talk. It can also provide the state with a reason to increase its supply of arms so as to keep even with or move ahead of an enemy's arsenal of weapons. The field of remote sensing satellites in general and reconnaissance satellites* in particular is a multi-billion dollar a year industry yet its roles and functions in the arms race are largely overlooked by the public, academics, and politicians alike.

There are six different types of satellites: reconnaissance, communications, navigation, meteorological, geodetic and interceptor destructor satellites. Because this paper is attempting to assess the significance of reconnaissance satellites, all other satellites will be given limited attention. Nuclear-tipped and laser satellites and their role in the arms race will be discussed briefly.

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*It is necessary to point out here that there is an important difference between remote sensing satellites and reconnaissance satellites. For the purposes of this thesis, remote sensing satellites are all satellites that obtain information about the earth or outer space. Reconnaissance satellites are those satellites which are used to obtain information by a state about itself or another state which is to be used for intelligence purposes. For the most part, telecommunications satellites will not be considered to be remote sensing satellites.

(1) Remote Sensing in History

Remote sensors have been a relatively recent phenomenon but the practice of remote sensing has been in use for many years. The French used balloons to conduct military reconnaissance observations during the battle of Fleurus in 1794.[1] As cameras had not been invented, the logistical information was somewhat unreliable. Two men would race behind enemy lines and observe the troop movements or sketch on a map the troop formations of the British. At times they would have to fly very low to avoid cloud cover. Unfortunately, this also left them susceptible to being shot out of the air. The same tactic was used during the Austro-Italian war of 1859. But photography per se (which literally means a light image) was not invented until 1839 by two scientists whose names are Niepce and Daguerre.[2] The first air photograph was taken by Gaspard Felix Tournachon in 1858. Tournachon conducted a series of experiments in which he used balloons to carry a camera for a birdseye view of the earth. He later put his experiments to more direct use when he became the commander of the balloon corps during the siege of Paris in 1870-71.

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[1]Ted Greenwood, Reconnaissance, Surveillance, and Arms Control, Adelphi Papers #88. (London: International Institute for International Affairs, 1972), p.2.

[2]Robert Reeves (ed.), Manual of Remote Sensing, 2 vols. (Falls Church, Virginia: American Society of Photogammetry, 1975), p. 27.

Between this period and World War I both aerial photography and the photographic process underwent considerable change. Dry plate photography simplified the photographic process while experiments in aerial photography were carried out in Europe and the United States. Various methods in air photography were tried including kites, planes and pigeons.

World War I can be credited with beginning the era of significant aerial photography. It was used by both the Germans and the allies for most of the war. Cameras for aerial use were being produced by 1915. Lt. Col. J.T.C. More Brabayon of the British Royal Air Force designed the first aerial camera in collaboration with Thornton Packard Ltd.[3] The practicality of using such an instrument as a weapon of war became most apparent to British military strategists.

> The introduction of aerial photography completely changed the tactics of war: a vast amount of military information was impossible to conceal from the aerial camera lens. Camouflage materials, dummies, decoys, and other deceptive devices were introduced, but proved to be expensive and, in general, unable to influence the precise record of aerial photography. It was found that photo-interpreters could predict the movements of the enemy by observing--from aerial photographs obtained at timed intervals--the varying amounts of rolling stock at important railheads, of ammunition at dumps, the appearance of new railways and Red Cross stations, and many other clues. Aerial photographs taken by the French Army at Dreslincour in 1917 disclosed the intentions of the Germans' to attack, and made it possible to plan countermeasures.[4]

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[3] Robert Reeves, Op Cit., p. 32.

[4] Ibid., p. 32.

The 1920's saw a slowing down of experimentation in aerial photography. But the 1930's and the Depression that characterized it saw an increase in aerial surveillance research and development. The New Deal, with its emphasis on agricultural production required the expertise of aerial photography. In 1934, the American Society of Photogammetry was established and has become an important ally in the advancement of both photogammetry and the photographic process in remote sensing.

World War II witnessed the start of a new era in remote sensing. Whereas the photoreconnaissance activities of World War I used single engine planes as mounting platforms for spying on the enemy, military planners in World War II employed rockets instead. New advancements in air photography were made prior to World War II. Cameras were developed that had faster shutter speeds, longer focal lengths and increased resolution. The Germans were aware that aerial photography would become an important tool in the war. General Werner von Fritsch, the chief of the German general staff, was quoted as saying at the beginning of the war, "the nation with the best photoreconnaissance will win the next war."[5] It is noteworthy that Germany led the world in photoreconnaissance by 1940.[6] The German V-2 rocket was the mainstay of this activity. As the war progressed, German aerial reconnaissance activity decreased steadily

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[5] Ibid., p. 32.

[6] Ibid., p. 32.

as the Germans were solowly driven back from strategic points in Europe. As the war progressed the British and American use of aerial reconnaissance increased steadily. Such a decision (to rely more heavily on photo-reconnaissance) was the result more of necessity than of strategy for the British. The retreat from Dunkirk in 1940 cut the allies off from an important source of military information and military intelligence. The information that was obtained as a result of this new spy tool helped to turn the war effort towards the allied forces. Among the more significant achievements of military photoreconnaissance in the early part of the war were: 1) the detection of German barges in canals along the coast of France and the Low countries in 1940 with the result that an effective counterattack by the British helped to stop the invasion by the German army and Navy 2) the air photos helped the British to keep track of German naval movements and keep them ineffective on the seas.[7]

During the latter part of the war, and especially after the United States had joined the allied forces, photoreconnaissance was used on a daily basis. Its effectiveness in helping the allies win the war can hardly be overstated: 1) The U.S. Army Air Corps flew over 500 photo-reconnaissance flights in preparation for the invasion of Sicily.

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[7] Ibid., p. 33.

2) Three months prior to the invasion of Italy, another 100 photo-reconnaissance missions were flown.

3) The enemy-held ports in the Mediterranean were photographed by reconnaissance planes at least once a week.

4) From May 1942 to March 1945, the German rockets and rocket concrete sights were under constant observation and were often neutralized by the allied forces.

5) The invasion of Normandy was planned on the basis of photoreconnaissance pictures which detailed enemy installations and underground plants and communications lines.

6) The operations used for siezing the strategic town of Weiseien towards the end of the war were conducted entirely with the information obtained from aerial photographs.[8]

The war had taught military planners that photoreconnaissance would be a necessary component in any military complement. In the post- World War II era the United States and the Soviet Union began a cold war and each side realized the need to place into orbit a synchronous satellite which could take pictures of the other country from space and telemeter that information back to earth. A number of formidable barriers had to be overcome however. Although scientists in both countries were learning more about the behavior and characteristics of the atmosphere, it was still not clear how a satellite might be placed into orbit and follow a

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[8] *Ibid.*, p. 34.

set path around the earth without falling into earth (an effect known as atmospheric drag) or escaping. The rocket boosters were not strong enough either. To allow a satellite to leave earth's orbit, a rocket must travel 36,000 km./hr. to escape the gravitational pull of the earth and to achieve an earth orbit, but the fastest rocket at the time (the V-2) could only travel half that speed.

Remote sensing did not become a reality until the 1960's. The developments in space technology during the 1950's, however, were crucial to the eventual use of remote sensing as an instrument of observation.

It is now necessary to examine separately the developments that led to remote sensing within both the Soviet Union and the United States during the decade of the 1950's. During the 1950's many Soviet scientists thought it was impossible to place an artificial satellite into orbit. But the brilliant Soviet scientist Sergi Korolev argued in 1954 that it would be possible to place an artificial satellite into orbit within a short period of time.[9] He was rebuked by his colleagues but in 1957 the Soviets, largely to the credit of Korolev, had placed an artificial satellite into outer space. When Sputnik I was placed into orbit on October 4, 1957[10] it stunned the world. The satellite (the first object

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[9] "New Times" ed. by V. Gubarev (volume 40, no. 77, Dec.7, 1956)

[10] Sputnik I was intended to be launched on September 17, 1957 to commemorate the one-hundreth anniversary of Tchaikovsky's birth but the launch had to be delayed due to technical reasons.

ever to be placed into outer space by man) was round in shape, weighed 67 kilograms (184 pounds) and was 58 cm. (23 inches) in diameter. The satellite was launched into space in a rocket which then separated from the satellite. The Sputnik 1 satellite stayed in orbit for ninety-four days before falling to earth.[11]

Sputnik had a multi-purpose role in space. Firstly, orbital dynamics were confirmed and the satellite provided scientists with information on the behavior of a satellite in space. Sputnik 1 obtained information about the physics of the upper atmosphere. The temperature of space at various altitudes was monitored and this provided key information for later manned and unmanned space launchings.

The orbit of Sputnik 1 was elliptic. Its apogee, that is, its farthest distance from the earth, was some 941 km. above the earth's surface. The speed approached some 18,000 miles per hour so that it circled the earth once every ninety minutes. The perigee of the satellite (the closest point to the earth) was 227 km. (141 miles). The combination of orbital movement and earth rotation meant that the satellite passed over most inhabitable areas of the earth once a day. For many scientists, the weight of the satellite (it weighed approximately 67 kg.) was as suprising as the launching

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[11] Kenneth Catland, Op.Cit., p.28.

itself. Design studies that were in progress in the United States had determined that only a lightweight satellite could be made to stay in its intended orbital path. Also, the ratio of rocket booster to satellite weight is approximately 1000 to one. Therefore, the launching rocket that took Sputnik into space must have been approximately 9000 kg.

The second Sputnik satellite was launched on January 14, 1958, only three months after the first one. This satellite carried a dog. The purpose of using a dog was to test for conditions of weightlessness in space. This satellite weighed nearly 450 kg. (one-half ton) and conducted tests of solar radiation in the short-wave, ultra-violet and x-ray region of the electromagnetic spectrum. The satellite also contained an apparatus for conducting tests of temperatures and pressures in space. Sputnik 2 fell out of orbit sooner than planned because of improper calculation of the effect of atmospheric drag.[12]

The launchings that were made by the Soviet Union at this time were aimed primarily at understanding the behavior of the zones that surrounded the earth. Mounting cameras on these satellites was still not possible up to this point in time. But the purpose of such testing was in fact military.

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[12]It is important to note the effect of atmospheric drag on a rocket. Because of atmospheric drag, a satellite launched into low orbit will decay quicklyand either fall to theearth or be destroyed by friction, unless the satellite has a rocket motor which can periodically raise its orbit.

As was the case with the Soviet Union, the American scientific community in the early part of the 1950's felt that the possibility of placing a satellite into space was very small. A top secret Navy report in 1946 recommended to the now defunct Bureau of Aeronautics (Bu Aer) that a group should be established "for the purpose of constructing and launching an Earth satellite for scientific purposes".[13] "The result was a U.S. NAVY /Bu Aer study for a single-stage, LO_2/LH_2 rocket capable of injecting itself into orbit. The estimated cost of the project (at 1946 prices) was $8,000,000 and, to ease its passage through official channels was given the prosaic title "High Altitude Test Vehicle".[14] The project was then turned over to the newly formed Research ANd Development (RAND) Corporation. RAND did fulfill the task and designed a multi-purpose launch vehicle that could place a payload into circular orbit. But for various reasons (mainly because the emphasis at the Pentagon was on developing America's nuclear forces) the project was abandoned. A similar project completed in 1951 by a British group (who were unaware of the RAND project) designed a rocket that was lighter and more cost effecient than that proposed in the American plan. Throughout the 1950's, improvements were made in satellite technology but more important considerations for

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[13] Robert Reeves, <u>Op Cit</u>., p. 26.

[14] <u>Ibid</u>., p. 26.

the U.S. government allowed research to continue only at a slow pace. The Department of Defense was concentrating its efforts on strategic bombers and missiles. The Defense Department was intent on maintaining a large degree of superiority over the Russians in this area.

The launching of Sputnik I shocked the Americans as to how far the Russians had come in their space program and how intent they were in achieving superiority in outer space. In the year previous to the launching of Sputnik I there was a hurried effort at the Pentagon to revive the satellite space program which up to that point had been existing in a state of limbo. Within three months of the Soviet launch Explorer 1 was launched from Cape Canaveral in a south easterly direction where it could crash into the Atlantic ocean should there be an equipment failure.[15]

The characteristics of Explorer I were far different from those of Sputnik I. It was one meter long and 15.2 cm. in diameter. It weighed 14 kg.(31 pounds). The data that was collected was kept in capsules and these capsules were dropped at strategic points to receiving stations on earth. The lighter weight of Explorer allowed it to be inserted into a higher orbit than the Sputniks were capable of doing.[16]

The Defense Department's reconnaissance program was officially

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[15] Ibid., p. 28.

[16] Ibid., p. 28.

(although not publicly) initiated in November 1958. This program, called WS-117L, consisted of three separate projects: Discoverer concerned itself with developing photographic reconnaissance techniques; SAMOS (SAtellite Missile Observation System) was to be a photographic reconnaissance satellite system; and MIDAS (MIssile Defense Alarm System) was designed to provide early warning of an enemy attack.[17]

(2) Launching a Satellite

There are two reasons why satellite photography is so important to the military planner. Firstly, "the face of the land looks to the sky".[18] On earth, man cannot easily delineate one resource boundary from another. From space, man has the power to characterize and plot on paper the land that he wishes to use. Secondly, man can view large areas of land from a single point in space and time and under relatively uniform conditions.[19]

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[17] Stockholm International Peace Research Institute, Outer Space Battlefield of the Future?, (London, Taylor and Francis, 1978), p. 29.

[18] National Aeronautics and Space Administration, Apollo 10 Space Program, NASA special publication 275, (Denver, Colorado: NASA, 1967), p. 1.

[19] Ibid., p. 1.

Remote sensing simply and literally means sensing an object from a remote point in air or space. An artificial satellite that is capable of remotely sensing objects must fulfill the requirement of transferring a clear picture or design of the area being searched. Designing a satellite, placing it in space and keeping it functional is a challenging technological demand.

> In the first place, because it costs many thousands of dollars per kilogram to launch a satellite, its cost (in orbit) is equal than the cost of an equal mass of pure gold. Consequently, the designer must something of a genius at the task of minimizing weight. Superfluous "safety factors" which in reality are often only factors of ignorance cannot be tolerated and only the strongest, but lightest materials can be used.

Satellite designers must combine simplicity of design with a system that cannot under any conditions break down and that can perform complex tasks when commanded. This means that a reconnaissance satellite must be infallible in both the pictures it takes and in the orbital path that it is expected to follow.

The first problem that a scientist must face is putting the satellite into the proper orbit. Issac Newton demonstrated that in order for a satellite to stay in orbit it must be placed at least 160 km. (100 miles) above the surface of the earth. The speed of the satellite, once it reaches space

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[20]Richard Porter, The Versatile Satellite, (London: Oxford University Press, 1977), p. 18.

can be increased and the satellite will therefore be placed into a higher orbit in space. But the satellite cannot travel any faster than 10 km. sec. (7 mps) or it will attain escape velocity and will leave the earth's orbit altogether. Remote sensing satellites whose function is aerial surveillance are placed in a higher orbit than close look satellites. The area surveillance satellites have a longer lifetime than the close look satellites because they are not as influenced by air drag.

> In a typical launch the booster motors put the satellite in an elliptical orbit whose apogee lies at the correct synchronous altitude (about 22,300 miles or 35,800 kilomaters). The satellite is then started spinning and tracked while it completes four to twelve orbits. It is so aligned that the thrust of the final, or apogee, motor (fired at apogee) will both place the satellite in a circular orbit and move the plane of the orbit to the plane of the earth's Equator. The axis of spin is then adjusted to be parallel to Earth's axis. Further orbital corrections can be made by pulsing the jets provided for attitude control and station keeping (maintaining the desired position above the Earth). The position and attitude of the satellite are determined by radio observations from Earth and from information transmitted to earth from solar and Earth sensors on the satellite.[21]

The satellite that takes a picture of a large area may show military planners something peculiar. Contrary to popular belief it is not possible

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[21] "Satellite Communications" Encyclopedia Britannica, vol. 16 (New York: Encyclopedia Britannica, 1975), p. 263.

to tell the satellite to "go back" and take more detailed pictures of the particular sight. The satellite follows a predetermined orbital path and to command the satellite to leave its orbit would be a decision that would be made only under the most extreme of circumstances for the new orbital route could make the satellite lose years off of its planned lifetime. What the military planner must do is command a close look satellite to take a series of pictures of the area in question when its orbit does in fact pass within focal range of the target.

Depending on the type of satellite and its function the satellite will move in either an easterly or a westerly direction.

> A particularly interesting orbit is the one for which the period is exactly 24 hours, because a satellite in such an orbit revolves about the earth in exactly the same length of time that it takes the earth to rotate on its own axis. This orbit is called an earth-synchronous or geosynchronous orbit. If a geosynchronous orbit lies at the plane of the earth's equator, the satellite in it will appear to an earthly observer to remain stationary while the sun, moon and stars march past it in their daily progression across the sky. Such a satellite is therefore known as a geostationary satellite. If the geosynchronous orbit is inclined to the equator, the satellite will appear to trace out a figure of eight once each day. An observer or an optical instrument such as a telescopic camera in a geostationary satellite would always see the same portion of the earth's surface with the dawn, daylight, twilight, and night phases progressing

> across it every 24 hours. The advantages of the earth-synchronous orbit for such purposes as television broadcasting, radio-relay stations, and certain kinds of earth observations are obvious.[22]

A geosynchronous satellite poised over the United States could give the Soviet Union a 24-hour eye over the enemy. The same holds true of course for the United States. The drawback of positioning such a satellite in this manner is two-fold. First, although the satellite could get a big picture of the enemy it would have to rely on close look satellites to provide the detail that would be necessary for a more thorough examination. A second problem is that a geosynchronous satellite would be a "sitting duck" for the enemy country that it was spying on for it could be knocked out of space fairly easily. For this reason a satellite that travelled in retrograde orbit (i.e. against the direction of the turning earth) could be less susceptible to any enemy strike.[23]

> Reconnaissance satellites are normally launched by a powerful rocket into an elliptical orbit round the earth at a height varying from about 80 miles at perigee and up to 200 miles at apogee. The time taken for them to complete one orbit varies with the height but is usually about 90 minutes. The orbit is as far as possible arranged so that it is lowest at the target area and is synchronized so that the satellite arrives at this area when the sun is in the best place for illuminating the target.[24]

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[22] Samuel Porter, Op Cit., p.9.

[23] It should be noted that when a satellite travels in retrograde motion its orbital path, although predetermined, does in fact vary slightly due to conditions of space. This makes it a more difficult target for an anti-satellite missile.

A spacecraft becomes a satellite when it makes more than one circuit around the earth by relying on the earth's gravitational pull and not on any motor.[25] The satellite's shape must remain reasonably compact and it must be able to withstand such forces as radiation pressure, solar wind, electromagnetic fields and the gravitational attraction of the sun and moon. The boost that a satellite is given from the launching pad on earth is vital to determining its orbital lifetime. A boost into outer space that is weak (i.e. 8 km./sec.) will substantially reduce the amount of time that the satellite will stay in orbit. It is important that the satellite be placed into space at an exact speed and with a precise boost. The satellite is actually carried into space in a rocket and it is then launched into outer space once the rocket has reached an orbit that closely approximates the desired orbit for the satellite. This process requires exact calculation and is a costly endeavor.

Satellites remain in orbit because of the earth's gravitational field. It should be noted by the reader that the gravitational force is so strong that, even at far distances from the earth, the

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[24] Royal United Services Institute for Defense Studies (ed.) Rusi and Brassey's Defense Yearbook, (London: Royal United Services Institute, 1981), p. 272.

[25] In fact a thrust motor is provided on most satellites today because it extends their life in orbit.

satellite can remain in orbit for years (some satellites that orbit at 130,000 km. from earth's center have been in orbit for eight to twelve years and have shown no apparent signs of orbital instability). At distances that are greater than 92,000 km. from the earth's center the only perturbing accelerations are those due to the sun and moon.[26] However, their magnitudes, even at distances of 185,000 km. from Earth Center (EC) are less than one percent of the earth's gravitational attraction.[27] It should be noted however, that at a distance of 555,000 to 925,000 km. from EC the satellite is no longer an earth-orbiting satellite in spite of the fact that it might maintain a crude earth ellipse. The sun exerts almost no effect on the motion of a satellite. The gravitational pull of the earth is too strong for the satellite to be affected by either the moon or the sun. It is estimated that a satellite would have to be 900,000 km. from the earth in order for the sun to influence a satellite's orbital behavior.[28] In terms of military reconnaissance, such a distance would be useless in any case.

Reconnaissance satellites do not travel only in orbits that are strictly parallel with the earth's surface. Indeed this type of satellite

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[26] R.H. Frick, Stability and Control of Translunar Earth Orbits, (Santa Monica: Ca., RAND Corporation, 1973), p. 1.

[27] Ibid., p. 1.

[28] Ari Shternfeld, Soviet Space Science, Foreward by Willy Ley, (New York: Basic Books Inc., 1959), p. 8.

(geostationary) is usually a telecommunications satellite. Reconnaissance satellites more often than not travel in an elliptical (east-west) direction but at closer distances to the earth than geostationary satellites or those travelling in a north-south direction. Many of the photoreconnaissance satellites in use today travel in elliptical orbit. Their orbital behavior differs in comparison to the satellites that travel in north-south orbits. This is because the earth is not perfectly spherical but contains a bulge at the equator. This bulge can especially affect the satellites in low orbit and scientists must adjust for this in plotting a satellite's direction. The greatest anomalies in the shape of the earth occur over the Western Pacific, the Indian Ocean and Antartica.

Up until the present neither astronomers nor physicists have been able to define where air space ends or where outer space begins. This has posed considerable problems for the users of reconnaissance satellites. This problem shall be discussed in detail in chapter II but the matter of defining outer space and where its boundaries begin has posed some key problems for scientists and lawyers alike. There is no point per se in which a satellite reaches outer space.

> ...the earth's atmosphere has in fact no limit, for it gradually grows thinner and thinner, until the trace of air becomes imperceptible. The

> boundary between atmosphere and space is "entirely arbitrary" from the scientific viewpoint. One half of the entire mass of the atmosphere is below 3.6 miles, however, and 97% of its mass is below 18 miles.[29]

The lowest perigee point in which a satellite can stay in orbit is known. It is at a distance of 80 km. from the earth's surface. There are four orbital ranges within which a satellite can have a useful life. They are: 1) low circular which lies at a distance of 80 -160 km. above the earth's surface; 2) low elliptical which lies 160-240 km. above the earth; 3)mid-range circular which is 240-600 km. above the earth and; 4) distant geosynchronous which is 600-1000 km. above the earth.[30] These areas are called the low orbit ranges. Almost all reconnaissance satellites orbit within one of these ranges. The lower the orbit, the faster the satellite will move. In principle, the lower the satellite's orbit, the easier a target it becomes for a ground-based anti-satellite missile to destroy it. Nevertheless, remote sensing satellites will almost always be found in the range between 160 and 1000 km. It is only remote sensing satellites which are found in this range, the majority of which are reconnaissance satellites. As previously explained, satellites are in some ways more vulnerable to enemy attack because they are closer to the earth. They

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[29] Philip Jessup and L. Godrich, Controls For Outer Space, (New York: Columbia University Press, 1959), p. 196.

[30] The number of molecules in one cubic centimeter of space at an altitude of 100 km. is about three trillion times smaller than it is at sea level. Still, scientists cannot agree that this constitutes outer space.

are considerably more expensive to build than telecommunications satellites and their orbital lifetime is much shorter than satellites that are in higher orbits. The following table will illustrate the point.[31]

Table I

Altitude (km)	Orbital Lifetime (days)
125	0.01
149	1
198	4
247	12
308	34
347	58
399	104
449	173
500	365

[31] Ari Sternfeld, Op Cit., p. 26.

The above figures assume a satellite that is spherical in shape with a diameter of 0.5 Meters and a weight of approximately fifty kilograms.

(3) Methods of Remote Sensing

There are two main types of remote sensing. Those which utilize the visible spectrum of the universe and those which use the invisible. The visible spectrum is only effective for cameras which operate in daylight and which are intended to be used for surface photography. The second type of remote sensing utilizes the invisible portion of the electromagnetic spectrum. The camera which utilizes daylight conditions and intends to take pictures of above-ground features must also be engineered so as to provide the analyst with clear pictures that contain both high resolution and clear images of the image being photographed. This task is anything but easy. Even at the lowest point in apogee which at an extreme instance might be 80 km. - most apogee points are higher than this - the camera must be able to take pictures from very high elevations and deliver information that is accurate. The satellite moves at a speed of at least 7 km/sec. This has meant that scientists have had to invent cameras which would overcome the complications of enormous speed (both of the camera and the turning earth - which could tend to blur the picture) and of height (which would cause poor resolution). The camera would also have to be able to take pictures which could adapt to the spherical shape of the earth and which would accurately detail differences in elevation. Other more complicated problems remain such as penetrating cloud cover (Moscow is cloud covered for 80% of the year) and taking photographs at night time when no natural light is available.

> The two most important characteristics of aerial films which determine their use and image characteristics are spectral sensitivity and resolving power. The speed of a speed emulsion is almost universally tied to its resolving power. A fine grain (high resolution) film will have a relatively slow speed, limiting its use under marginal lighting conditions in cameras that have slow lenses, or in situations where the required lens shutter combination is inadequate to stop blur or motion. A coarse grain film has a higher speed, but pays a penalty in resolution.[32]

Table II contains a diagram of the electromagnetic spectrum (EMS). The EMS details the range of wavelengths that occur, ranging from very long waves of energy (e.g. radio waves) to very short waves of energy (e.g. cosmic waves). The following page details the entire EMS, including the visible portion of the spectrum.

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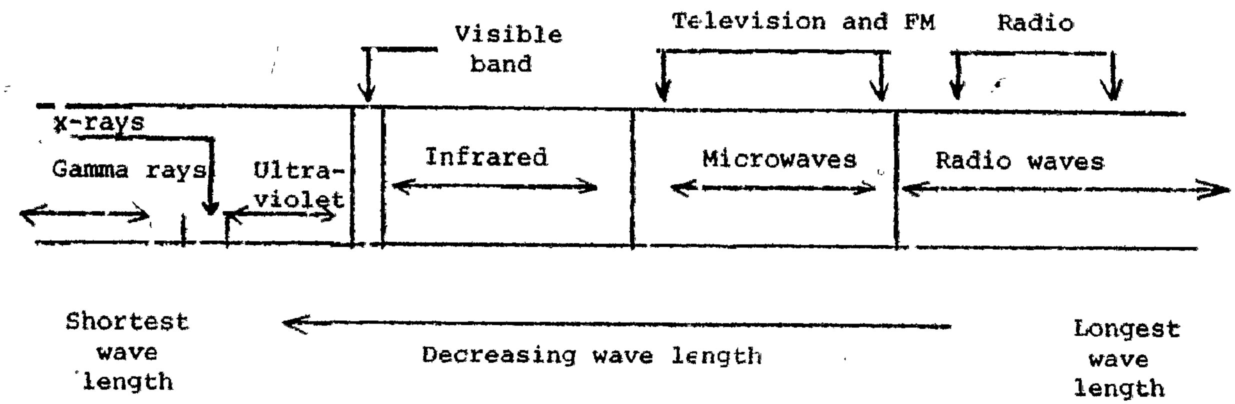
[32] Dick Kroeck, Everyone's Space Handbook, (New Mexico, University of New Mexico, 1976), p. 58.

Table II

Electromagnet Spectrum



As the diagram illustrates, the visible portion in fact occupies only a very small portion of the EMS. Scientists are now able to use nearly every part of the EMS in the field of remote sensing. Some radiation techniques, such as infrared and x-ray, are sometimes used in conjunction with each other in photographing the earth while some portions of the EMS have found little application in remote sensing. This will be discussed in part later in the chapter. The following pages will examine some of the most often used methods of remote sensing.

Sideways Looking Airborne Radar or SLAR is one of several effective means by which information can be gathered by satellite. More traditionally however, SLAR is used in high flying aircraft. SLAR was originally developed to look sideways from a reconnaissance plane as it would fly past enemy lines.[33] SLAR can take pictures through clouds or at night.

> Any form of air to ground search radar can be used for reconnaissance, but the most common type is sideways looking. Basically this means that the aircraft transmits radar signals downwards and outwards on either side of the aircraft. The resultant returns from the ground are recorded and form a radar map of the country on each side of the aircraft. Arrangements are made to annotate the film on which the record is made with the aircraft's position taken from its navigational system in much the same way as is done in the Jaguar pod.[34]

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[33] This was developed prior to World War II by the Americans.

[34] Royal United Services Institute, Op Cit., p. 280.

SLAR was first developed in 1954 by Westinghouse Corporation under the sponsorship of the USAF. A separate program funding by the USAF (this time to Texas Instruments) aimed at attaining the highest possible resolution at a short range and from a low altitude.[35] Both these programs were shelved but were later combined in a project awarded to Westinghouse in 1961.

SLAR systems can be divided into two classes which are 1) real-aperture which uses a narrow angular beamwidth to get highly detailed, fine resolution pictures, and 2) synthetic aperture radar (SAR) which uses a broader antenna beam which relies on data processing to obtain the desired image.[36] Of the two systems, the second, SAR, is more popular because real-aperture is limited in the photographs it can take relying on low altitude pictures. In a satellite this method becomes almost redundant. SLAR uses three components to obtain its image; 1) antennas (which transmit short microwave energy pulses to the ground and receives back reflected energy from the terrain), 2) a cathode ray tube (which converts the energy into an image) and 3) photographic film which records the image.[37] SLAR uses conventional black and white films

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[35] Robert Reeves, Op Cit., p. 42.

[36] Ibid., p. 42.

or ultra-violet sensitive film to record images.

SLAR is important to the military analyst mainly because of its abilities to penetrate not only the densest of cloud cover but soil as well. SLAR is one of the few methods of detection available to the analyst that can penetrate natural camouflage to reveal underground military installations or missile silos. SLAR can give important information about the types of minerals in the ground or about fault lines that can be potentially hazardous to a particular area. So important was SLAR to the American military that the SLAR system was not released from military security classification until 1970.[38] Until the development of Landsat, SLAR was the single most efficient way of obtaining information about the earth. Its uses are now concentrated on obtaining information from aircraft. Landsat and other photoreconnaissance satellites developed after it can produce finer detailed pictures from over 100 kilometers above the earth but SLAR is still considered to be an effective and reliable means of remote sensing.

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37 Ynez Hasse, "Remote Sensing and Its Applications" Western Association of Map Libraries, March, 1972, p. 27.

38 The Russians had already developed a sophisticated system of their own.

All objects at finite temperatures radiate electromagnetic energy. Some of this energy lies outside of the visible portion of the spectrum. Of the entire electromagnetic radiation in the universe, only a small portion is visible as has already been discussed. This portion is visible to the human eye. The rest of the spectrum can only be detected by artificial means. In the near end of the electromagnetic spectrum the electromagnetic waves are those of radio and television. Closer to the visible spectrum exists radar and infrared. After infrared comes the visible portion of the spectrum, i.e. colour. After the visible comes the invisible again, the segment which has the highest frequencies. These frequencies are ultra-violet rays, x-rays, and gamma rays.[39]

Remote sensing by satellite can use any or all of this spectrum to obtain information. Satellite sounding, in which radio waves are bounced off of the earth to detect among other things, an underground nuclear explosion, is a recent development in remote sensing[40] which will have

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[39] It should be remembered that remote sensing does not have to imply the taking of "pictures". Any sensing technique is remote sensing as long as it is taken from a remote area or point in air or space. Nevertheless, whenever "remote sensing" is used it always refers to sensing via the medium of air or space unless remote sensing is specified as being ground based or underground based. For the purposes of this paper, remote sensing will always refer to space based sensing.

considerable military implications for the future. Radar is a technique of remote sensing that has been in use since the 1950's. The most effective means of remote sensing is through infrared detection.

Most of the natural radiation of the earth falls within the infrared zone. Infrared sensors can detect objects at finite temperatures. All natural radiation from the earth is less than 1000 °Kelvin. Infrared can be used at night because the radiation continues to be emitted by the objects of interest (i.e. the object gives off heat). Because the wavelengths of energy that are emitted depend on the object's temperature, infrared sensors can easily detect objects through camouflage or through objects that are dug deeply into the ground (e.g. missile silos because their temperature is warmer than the surrounding ground).[40] The ability of infrared sensors to detect objects by heat emission gives infrared detection many strategic advantages over most other types of remote detection. A crystal of indium antimonide can spot a forest fire long before it spreads.* Infrared satellites can also use television for detection of objects on the ground thus providing military analysts with "live" pictures of a

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[40] Robert Rudd, Remote Sensing, (Denver: University of Denver, 1976), p. 27.

*Crystal Indium Antimonide is the key chemical component in an Infrared sensor.

particular sight.

> Television is a useful reconnaissance device for the better viewing of objects on the ground or on the sea. It can be fitted with image intensification for viewing objects under the same conditions. Finally, thermal imagers also have their use, particularly at night, for detecting the infrared rays emitted by objects on the ground or sea. All three of these devices have a wider application at sea for use by maritime patrol aircraft.[41]

Infrared cameras can take these wavelengths of invisible radiation and can produce pictures which can identify objects and soil types that would not be discernable by the human eye even under daytime conditions. Infrared energy is very close to the visible part of the EMS.

> By extending the sensitivity of film a little beyond the red end of the spectrum, infrared film was (is) obtained. Although much of the radiation from the sun is light energy, some of it is energy with wavelengths longer or shorter than those visible to the human eye. Infrared film is sensitive to some of the longer wavelength energy as well as to light energy.[42]

The technique of colour enhancement allows the analyst to obtain images that would be readily identifiable of structures of both above ground and underground. Infrared film is sensitive to both light energy and the longer wavelengths of the EMS. Live vegetation reflects better

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[41] Royal United Services Institute, Op Cit., p. 281.

[42] Robert Rudd, Op Cit., p. 3.

in the infrared than does dead foliage. For example, in this case, live vegitation appears a healthy green colour while dead vegetation appears a dull red. There are important military implications for this type of imagery. One side can quickly learn of the enemy's intention to develop a particular area of land. He can determine what areas are used for human requirements as opposed to those which are used as garages or as storage bases. Infrared photography can be sensitive to a large number of above ground and below ground activities that were heretofore impossible to determine.

Infrared remote sensing was first used in the Earth Resources Technology Satellite - the precursor to Landsat. Infrared sensing is the key component of the TIROS weather observation satellite series. So effective was this method of weather observation that a total of ten TIROS satellites were placed in orbit. The same method was used in the ESSA weather satellite series.

(4) Weather Satellites - The State of the Art

In 1966 the first truly sophisticated weather satellite was launched by the Americans. Weather satellite act as a barometer for developments in the field of remote sensing. Although the purposes of weather satellites are primarily peaceful, they can be used for spying. Weather satellites act as an indicator of developments taking place in the various areas of satellite surveillance. The ESSA (Environmental Satellite Service Administration) satellite series provided daily worldwide pictures of the earth. This satellite fulfilled a dual role, acting as both a weather satellite and it provided experts with information concerning the weather patterns that occurred over Soviet territory.

In 1969, the second set of meteorological satellites was placed in orbit. ITOS (Improved Tiros Operational Satellite) consisted of a series of satellites each with advanced photographic methods. Although the physical abilities of military reconnaissance satellites is top secret, the capabilities of ITOS indicates the level of advancement that reconnaissance satellites had achieved by this date. ITOS-1 provided direct-readout, automatic picture transmission. This was the first satellite to possess this function. ITOS-1 was also capable of storing information for later transmission and processing. It was the first 24-hour satellite to provide both day and night photographs. The ITOS-D satellite employed high and medium range resolution radiometers, a vertical temperature profile radiometer, and a solar proton monitor. The ITOS satellite series lasted until 1978.

Following the ITOS series came the NOAA satellite series. NOAA (National Oceanographic and Atmosphere Administration) was sun synchronous and operated in both the visible and infrared bands of the EMS.

> The visual pictures show features of the earth's surface as well as atmospheric phenomena (clouds, etc.) much like an ordinary photograph. The infrared image displays the different temperatures of land and water surfaces... A picture can even be obtained at night when operation in the visible spectrum is not possible.[43]

The most recent satellite series ejected into outer space by the Americans illustrates the substantial developments in photoreconnaissance that took place in the seventies. The TIROS-N (Television and Infrared Observation Satellite) are capable of both data transmission and telecommunications. TIROS indicates that a trend is taking place towards the deployment of multi-function satellites.[44]

The capabilities of satellites in the 1970's illustrates the enormous advances that have taken place not only in the area of weather reconnaissance, but in military reconnaissance as well. In fact, there is good reason to believe that weather satellites and the capabilities that they possess are crude in comparison to the technical abilities of military reconnaissance satellites. ITOS-1, for example, could provide analysts with both above ground and underground images. The second series

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[43]It should be noted that the periods of time indicated only specify when the satellites stopped being functional and not when they ceased being in orbit. A number of weather satellites have remained in space - some as far back as the ESSA series.

[44]Kenneth Gatland, Op Cit., p. 69.

of TIROS satellites TIROS-N was a polar orbiting satellite that would transmit information in real time. Although this satellite was promoted as a weather satellite its instrument payload consisted of an infrared sounder, a high energy proton, and an alpha particle detector.

Another weather satellite worthy of mention is the SMS/GOES satellite (Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite System). It too operated in both the visible and infrared and could provide a variety of environmental information (e.g. the speed of a river) and could monitor activities of other satellites in outer space as well.

The satellites described above should provide the reader with an idea of the enormous capabilities of remote sensors. It should be noted that the capabilities of these sensors are generally unclassified. The abilities of defense satellites (whose functions are top secret) would allow one to conclude that remote sensors used in reconnaissance can obtain information of a variety of both military and nonmilitary activities that have rewritten the meanings of espionage and military intelligence.

The Soviet weather satellites were always slower in development and deployment than were American weather satellites. Their functions and capabilities remain top secret but analysts have been able to derive some information about the capabilities of Soviet satellites by using close look cameras from the earth and the air and by following their orbits. Recent Soviet satellites have developed techniques that allow the satellites' engines to be powered by solar radiation. Cosmos 122 contains a camera with infrared sensors. Cosmos 156 is known to have carried out tests for a national meteorological distribution network. Recent reports suggest that the Soviet Union is about to launch a weather satellite in geostationary orbit.

The Soviets have always been slower than the Americans in the development of sophisticated weather satellites. Their first fully operational 24-hour weather satellite system was not deployed until 1967. The main reason for this lack of initiative was not due to a lack of technological knowhow. For the Soviets the need to deploy satellites that can collect information about NATO countries has never been as great because much information about such things as agriculture has always been publicly available. This has not been the case with the Soviet Union or with her allies.

In and of themselves, weather satellites are tools of the meteorologist. But a number of key benefits can be derived from using weather satellites that are only partially applicable to weather science. A weather satellite can tell the military analyst when a particular area is clear of cloud cover. This information can be vital because some earlier satellites carried limited supplies of film. Some satellites in orbit are now capable of supplying both reconnaissance information and a number of other services. It is not inconceivable to assume that future satellites will combine both reconnaissance and telecommunications functions that could virtually eliminate the need for all but a few satellites in outer space. Strategically, this scenario would present military planners with a number of problems and these will be discussed in the third chapter.

(5) Other Satellite systems

Contained below are a list of satellite systems which possess both military and nonmilitary capabilities but which are not classified as photographic remote sensors. The systems are:

a) Ocean Surveillance Satellites

Although the military reasons behind constructing ocean surveillance satellites are not completely known, it is believed that the Landsat-2 and Landsat-D (which was first launched in November 1982) have ocean surveillance capabilities. The Big Bird satellite belonging to the United States, and several Cosmos satellites have the ability to search both above and below the water. The purpose of these satellites in a military function is to seek out ships and submarines via infra-red techniques. Ocean surveillance satellites are already being deployed and used to locate schools of fish and to map the ocean floor. The strategic advantages that are gained by using these satellites cannot be very much in doubt.

b) Early Warning Satellites

The early warning satellites include the MIDAS and IMEWS (Integrated Missile Early Warning System) for the United States (and Canada) and selected COSMOS satellites for Russia. The satellite orbit must usually be a synchronous equatorial orbit in which the satellite remains in a fixed position relative to the earth. It is by noting this orbital behavior that analysts have been able to determine the number of launches of this type of satellite and there seem to be only two satellites (COSMOS 159 and 775) of this type that the Soviets have ever launched. But even with the United States there is little evidence of much money having been spent on the development of this type of satellite. This is probably because of the extensive ground and airborne radar systems which are already in place.

A second type of satellite which has had little use is the nuclear-explosion detection satellite. These satellites contain sensors that are sensitive to the x-rays emitted by an underground or above ground nuclear explosion. Although both countries have satellites with these capabilities, the priority for satellite research and development does not seem to have fallen into this area.

c) Radar Satellites

One of the more important techniques of remote sensing is the use of radar. Radar tracks the energy emission of an object. When a radio wave strikes an object, a certain amount of energy is reflected back to the source.

> In the pulsed radar system, radio waves are emitted in short, powerful bursts, focused in a narrow beam, and radiated into space by a slowly rotating antenna. The pulse duration is usually only one or two millionths of a second, with the interval between the pulses (called the silent period, when there is no wave emission being somewhat greater. When these bursts of energy, travelling at the speed of light -300,000 km/s- strike an object such as aircraft or ship, or precipitation such as rain, snow or hail, a small portion of the energy is returned to the radar set as an echo. Since the speed of the radio waves is known, and the direction in which the antenna is pointing can be controlled, it is possible to determine the distance and direction of a target. Detected by the radar antenna during the silent period, the echo is fed from the antenna to the receiver where it is amplified and transformed into a video signal for display purposes.[45]

Although extensive ground-based radar systems exist, radar satellites are capable of functions that ground-based systems cannot perform. These functions are evidenced with a particular type of radar satellite called Ferret satellites.

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[45] Canada, Knowing Weather, A publication of the Atmospheric Environment Series. (Ottawa: Environment Canada, 1982), p. 16.

d) Ferret Satellites

Ferret satellites are electronic reconnaissance satellites. Their military function is to pinpoint the locations of air-defense and missile defense systems that can detect radar installations. These satellites measure the radar's signal strength which may help in the enemy's penetration of the territory and/or destruction of the radar installation. They also are capable of locating military radio stations and can eavesdrop on military communications. Their orbit is slightly higher than that of reconnaissance satellites and these satellites are capable of functioning for several years.[46]

(6) Canada and Remote Sensing; ERTS and LANDSAT

Canada has not yet built a reconnaissance satellite(or a remote sensing satellite with both ecological and reconnaissance functions). But Canada is one of the few countries to possess the technical expertise to build a remote sensing satellite but has rarely done so. Canada has only one solely Canadian-built remote sensing satellite in outer space. The satellite (named ISIS) is used for astronomical research. Also, it collects information about the ionosphere. The only ground sensing satellites that

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[46] Information concerning the types of satellites that have been described were derived from various sources. For a comprehensive and complete description see: Stockholm International Peace Research Institute, Op. Cit.

Canada has ever been involved in were with the U.S. However, in this regard, Canada has been active in both research and development and data disemmination. ERTS (Earth Resources Technology Satellite) was first launched in September 1973 as a joint U.S. - Canadian effort. As its name suggests, ERTS was designed to map the features above ground that would provide information beneficial to geographers and scientists. In the course of its orbit, this sun synchronous satellite was used mainly to observe land in the western hemisphere.

The supplement to the ERTS program was the Landsat program. It is now the most important-photoreconnaissance program and one in which Canada plays a key role.

> Since the United States launched the first LANDSAT satellite... satellite...in 1972, the data cascading earthward down from this eye in the sky have exposed many of the earth's secrets to agronomists, foresters, geologists, environmentalists, and oceanographers.
>
> Travelling north to south at the phenomenal speed of 26,640 km/hr, Landsat surveys some 34,225 square km. of Canadian territory every 25 seconds from a flying height of about 900 km. The instantaneous "footprint" or sample size scanned by Landsat covers 1.1 acres on the ground.[47]

The Landsat satellite travels in a near-polar orbit at an altitude of 920 km. (510 miles) above the earth's surface. Its cycle is 18 days long appearing over the same point on the earth as it had appeared 18 days earlier. A cycle such as this allows a satellite to detect changes in almost

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[47] Ibid.,

every part of the earth within a short period of time.

Landsat's photography is among the most sophisticated and reliable of any satellte Landsat collects information of the earth through four different filters. Two filters use the visible portion of the electromagnetic spectrum (green and red) and two filters use the infrared. Combinations of these four filters can correlate almost any natural phenomenon on the earth. They can be used to obtain information about the earth at any time of the day or night, regardless of cloud cover. In Canada, for example, "The vigour or health of crops can be measured or monitored...by correlating them to historical yields, curves can be created that will help forecast what the crop is likely to be."[48] Since its first launching on July 23, 1972, three more Landsat satellites have been placed in orbit. Landsat-2 was orbited on January 22, 1975. Landsat-3 and Landsat-D have been orbited recently.

The camera system of Landsat contains a Multi-Spectral Scanner(MSS). This photographic technique was developed by the Canada Centre for Remote Sensing. The MSS records the ground features of the particular area and transfers them into a coloured image. The image produced does not accurately reflect the colours of the terrain but the colours do separate the various physical features of the terrain. Canada receives

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[48] Mike Minnich and Tom Messer, "Airborne DP Aids Remote Sensing" Canadian Datasystems, Extract, (March, 1981), p. 1.

the satellite transmissions daily at Prince Albert, Saskatchewan and Shoe Cove, Newfoundland. "These magnetic tape records are converted to images by the CCRS and are used throughout the country for a multitude of purposes from land use inventories through to forest fire fuel mapping, geological exploration, agricultural crop inventories, and as a source of map revision information."[49]

Landsat's MSS can cover an area of about 34 km. (23 miles) in one photo and can provide information not only on crop and tree types but on forest fires and the behavior of weather systems. It can identify schools of fish, wild life, potential earthquakes and coastal erosion of the earth. In Canada alone, Landsat satellites send back 75,000 photographs of the earth's surface every year.

Another special feature of the Landsat series is the Return Beam Vidicon, also invented in Canada. These cameras scan the surface of the land with an electronic beam and then receive the beam that is reflected back to a photomultiplier section where the image is made larger and sent back to an earth receiving station. Such detailed pictures, when the images are sent back to the receiving stations for analysis, can provide the West with almost unlimited information on all activities within the Soviet Union and elsewhere.

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[49] Dorothy Harper, Eye in the Sky, (Montreal: Multiscience Publications, 1976), p. 3.

(7) Remote Sensing in the Sixties and Seventies

The first photoreconnaissance satellite to be built and launched into outer space was the US Air Force DISCOVERER satellite. None of the first twelve satellites were able to deliver pictures because of orbital and photographic problems. The thirteenth launch (Discoverer 13) was made on August 10, 1960 and the following day a film capsule was retrieved in mid air by a specially designed plane.

The SAMOS satellite was designed to detect weapons that were being built or deployed in the Soviet Union. After the launch of SAMOS 2 in February, 1961, (the launch of SAMOS 1 in October 1960 was a launch failure) a heavy curtain of secrecy was put into place and the number of launches of satellites and their functions has remained a top secret. What is known is that seven new generations of reconnaissance satellites have been used by the Americans. The second generation (deployed in 1963) consisted of twelve recoverable satellites (i.e. they did not burn up in the atmosphere when they made their final descent towards the earth). In 1966, a third generation of satellites were launched. These satellites used infrared cameras and had improved photographic resolution. These satellites indicated the large investment that the U.S. was making in the reconnaissance satellite industry. As the new satellites offered improved technology, they also showed signs of being able to stay in orbit for longer periods of time. The most active series of developments in reconnaissance satellites came with the BIG BIRD satellites. Although the Big Bird is only one in a series of spy satellites that were being developed by the Americans it deserves special merit because it marked the entry of the United States into the sophisticated era of satellite spying. Big Bird was first launched on June 15, 1971. The satellite was pushed into orbit by the Titan 3-D rocket, directed southwest from Cape Canaveral towards the Pacific Ocean. The satellite was a massive 1800 kg (11 tons) in weight. It was 15.2 m (50 feet) in length and 3.2 m (10 feet) wide. The satellite would circle the earth every ninety minutes covering a different area of the planet each time. The orbit fo the Big Birds lasted 36 days and achieved an apogee as low as as 160 km.

It is difficult to state how the Big Bird actually functions as this remains classified military information. The camera systems on board the satellite (which uses both high resolution film and infrared techniques) can focus on anything suspicious and take colour photographs or infrared pictures.

> These photos are sent back to intelligence technicians in the U.S. in one of two different ways. Most are "Zapped" back electronically, much like a television broadcasting station, to U.S. receiving stations

> spotted strategically around the world. But when maximum resolution is called for, actual photos are dropped from Big Bird in a special re-entry packet. The packet is caught in mid-air as it floats by parachute through the latter part of its descent, by specially equipped aircraft based in Hawaii.[50]

The initial Big Bird satellites consisted of two main types: 1) the large area, wide coverage satellite with a wide angle camera and a low resolution and 2) the close look satellite which would process an increased resolution and would photograph only smaller portions of the earth's surface. The present day Big Birds have been able to stay in orbit for as long as 200 days and have been able to combine these functions. The satellite was equipped with an on board booster motor which helped it to stay in orbit longer. When the satellites useful lifetime ended it would be destroyed by a radio command from earth. Modified versions of Big Bird have appeared throughout the seventies. They have an average lifetime of about 160 days[51] and circle the earth every 88.8 minutes.[52] Present day Big Birds can detect missile sites, tanks, and guns with relative ease. They can also monitor troop movements and troop formation. This can provide the Americans with crucial strategic data.

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50 " How Satellites May help to Sell SALT," U.S. News and World Report, 15 May, 1982, p. 25.

51 Ibid., p. 25.

52 Ibid.

The present generation of Big Birds also carry six recoverable film capsules and their photographs are usually returned to the earth at two or three week intervals. The spacecraft has large antennas so that area surveillance photographs can be returned to the earth immediately. They also carry ultra - frequency equipment to provide communication with U.S. Strategic Air Command aircraft that is operating in the North Pole. A modern day, modified version of the Big Bird is the KH-11 which, in addition to taking pictures, can also process them and electronically zap back the results in minutes. This eliminates the problem of having to retrieve the film packets in mid-air and processing the negatives on the ground.

The Soviet Union was slow in the development of reconnaissance satellites because the need for verification of weapons and weapon systems was not as great as it was with the United States. Although American weapon developments are often top secret projects, the governments in the United States remain accountable to Congress and the public. Monies for weapons systems must be approved by Congress. Budget statements by the president must specify where the money for defense is going to be used. And the free press in the United States regularly reminds its listeners of what missiles and army equipment is being used, how it is being deployed, and how much it costs.

The Soviets, on the other hand operate on the advantage of being a closed system. The presidium acts as a rubber stamp for defense spending and the media as a voice for government policy. Budget statements are never made and money is delegated to various departments without the slightest need for government accountability to the public arena. In short, the Soviets have traditionally had less need for reconnaissance verification of the U.S. whereas the Americans have had to operate from a position of disadvantage.

Almost all of the satellites that are launched by the Soviet Union are named COSMOS. It is difficult to differentiate between those satellites that are military and those satellites which are intended to be used for "peaceful" purposes. It seems that those satellites with strictly reconnaissance functions are those which remain in orbit for less than fourteen days.

The Soviet reconnaissance program did not start to take shape until April, 1962, almost two years after the initial attempts by the Americans to launch this program. Cosmos 4 was launched in April, 1962. Its camera had a low resolution capability and the satellite fell out of orbit after only three days. A total of five capsules were launched that year each one remaining in orbit for only 4.5 days on average.[53] By 1964 and for most of the sixties, satellites were launched at the

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[53] Ibid., p. 25.

rate of almost thirty per year. All were the recoverable type and could be destroyed before falling into enemy hands.

The first improved version of the Soviet reconnaissance satellite was evidenced with the launch of Cosmos 208 in March, 1968. The satellite had a higher resolution, infrared optics, and an advanced booster motor that could bring a satellite back into orbit. In September, 1975 (in an apparent attempt to match the spectacular abilities of Big Bird) Cosmos 758 was launched. It resembled a modified Soyuz spacecraft (the Soyuz spacecraft were manned orbiting laboratories) and served as a multi-purpose satellite. The abilities of Big Bird were finally matched with the Salyut 345 space stations. The Salyuts were manned orbiting laboratories which could return film in a re-entry capsule.[54]

Author Ari Sternfeld has divided Soviet reconnaissance satellites into two main categories. In the first group the satellites are characterized as being recoverable. They return to earth intact after being in orbit for only a few days. These satellites operate at about 65 degrees to the equator. The second group, which operates at about 49 degrees to the equator, consists of smaller, lighter satellites which are allowed to decay naturally after a few weeks of active life.[55]

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[54] Kenneth Gatland, Op Cit., p. 77.

[55] Ari Schternfeld, Soviet Space Science, (New York: Harper Row, 1977), p. 141.

Generally, Soviet reconnaissance satellites are simple, single purpose, short life, recoverable products. This contrasts sharply with American satellites which are large, long life, multipurpose instruments. This does not mean, however, that the Soviets would possess a strategic advantage over the Americans if a full scale nuclear conflict were to occur. Although the Americans might be dealt a heavier blow if their satellites were neutralized, the fact that American satellites have been able to collect information over the years means that they would have gained in the long run for the more sophisticated intelligence that has been gathered over the years might give the Americans the advantage in fighting the war on earth. Thus, the purposes of the Big Bird, for example, would have already been fulfilled by the time a full scale nuclear war arose.

Satellites in outer space have added significantly to the arms race. But it would not be accurate to state that thev have brought the world closer to a full scale nuclear conflict, only that they have verified that a huge arms race is in progress. Reconnaissance satellites are at the forefront of arms verifications procedures. In spite of the predictions of some military analysts that the most sophisticated satellites in 1990 will be laser equipped, or nuclear tipped, current realities suggest that such weapons are still in the planning stages and that the most important object in outer space in a military axiom is the reconnaissance satellite.

Reconnaissance satellites are friend and foe to the "pacifist" and the "warhawk" alike. By keeping a check on the enemy, the reconnaissance satellite is one of the few means by which one may tell what the enemy is doing. It is also the best way of knowing what the enemy is doing. This brings honesty to the bargaining table at an arms reduction talk. But the presence of such inquisitive machines over one's territory can also increase the distrust that nations will feel towards one another. Reconnaissance satellites are the only medium in the military arsenals of the superpowers that can act as both a weapon of war and as a weapon of peace. Reconnaissance satellites are the only mediums which can both increase the arms race and decrease it. In fact, they do both.

This chapter has attempted to define what reconnaissance satellites are and how they work. The present generation of reconnaissance satellites have the capabilities to abstract information about the enemy that is vital to the security interests of both the state being spied upon and the state that is collecting the reconnaissance. All remote sensing satellites can be used in an intelligence capacity however peaceful their outward functions may be. In essence reconnaissance satellites have provided information that would have been almost impossible to obtain. It is because of this that the reconnaissance satellite has influenced the arms race so dramatically. Both the United States and the Soviet Union have used remote sensors as a vehicle for ensuring that the other side is adhering to any and all agreements that it signed in the area of defense. It is essential that each side be able to independently verify that what the opponent says it has, is in fact a true reflection of what it does have. The 1970's were especially important to the development of remote sensing because it was during this decade that the superpowers were able to develop satellites that could extend beyond the visible portion of the spectrum and that could identify missiles that were buried under the ground. Both the U.S. and the S.U. have benefitted from the developments in this area but the United States has gained the most. This is because the experiences of disarmament negotiations in the past have revealed that the Soviets have not been honest in discussing the numbers or types of nuclear weapons that they possessed. Reconnaissance satellites had enabled the United States to point out to the Russians that the numbers of nuclear weapons that they claimed to have were sometimes far short of the total numbers of weapons that reconnaissance satellites had in fact revealed there to be. Reconnaissance satellites have also been important in verifying when weapons and weapons systems have been broken down or otherwise dismantled. This, too, has been of benefit to the Americans because it revealed that the Soviets, during the middle part of the 1970's, were not always observing the agreements of SALT I.

Reconnaissance satellites have been of importance for the reasons mentioned above. They have ensured that missile agreements are being adhered to. At the same time, using satellites in such a way (i.e. to spy on the enemy) has served to increase tensions in both countries and, although the accessing of information about the enemy's missiles has always been of benefit to the country employing the satellite, it has served not only to increase tensions but has lengthened the bargaining process in the new strategic arms limitations talks. This subject will be discussed in detail in chapter three but the contradiction that reconnaissance satellites pose creates a curious dilemma for both military strategist and peace activist alike. Reconnaissance satellites are a weapon in the sense that they provide vital information about the enemy. They act as an instrument of disarmement for the same reason. These satellites may hinder the process of disarming because of the tensions and distrust that they create. But they also ensure that the weapons and equipment that an enemy claims to possess, are in fact a true rendition of what it does have.

Aside from these arguments, some other questions must first be answered before a full discussion of the strategic value of reconnaissance satellites is undertaken. What type of legal status does the reconnaissance satellite have? And what role will it play in the future, or in an actual nuclear exchange? These questions will be examined in the following chapters. Chapter two will study the problem of the legal dilemma of remote sensing.

CHAPTER II

THE LEGAL DILEMMA OF REMOTE SENSING

Much of legal history has been concerned with the rights of states to exercise jurisdiction over their own territory. The law of the sea was the first to establish an area as res nulius. Many of the arguments as to the rights of states in air space did not actually occur until the early 1800's because there was little need to dispute the sovereign rights of air space. With the advent of the first balloon flights in the early nineteenth century, it became necessary to define the rights of states in the exercise of control over their own air space.

The earliest accounts of upper boundary limits are frought with confusion and controversy. Medieval lawyers such as Grotius "recognized freedom of space at an altitude beyond the range of a hunter's weapon".[1] This left men to ask questions such as, how tall is the hunter?, what type of weapon?, at sea level or on the highest mountain?. In Roman law the owner of a piece of property owned both the air space[2]

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[1] Andrew Haley, Space Law and Government, (New York: Appleton-Century Crofts, 1963), p. 77.

above him and the earth below him that was equal to the width of land that he held.

One of the universal statements about freedom of the seas came from Hugo Grotius, the seventeenth century Dutch lawyer. In his classic work Mare Liberum (1690), Grotius directly challenged the claims of some states that they alone held exclusive jurisdiction over the high seas.

> That which cannot be occupied, or which never has been occupied, cannot be the property of anyone, because all property has arisen from occupation... All that which has been so constituted by nature that although serving some one person it still suffices for the common use of all other persons, is today and ought in perpetuity to remain in the condition as when it was first created by nature.[3]

It was not until the nineteenth century that the opinions of Grotius were finally accepted. Today, the principle of territorial claims to outer space are in fact similar in nature to the claims to the high seas.

(1) Events Leading to the Outer Space Treaty

On December 7,1944, delegates from around the world met in

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[2]Modesto Seara Vazquez, Cosmic International Law, (detroit: Wayne State University Press, 1965), p.28.

[3]Wyndham Place Trust, Man's Wider Loyalties, (London: Plutchinson and Company, 1970), p. 91.

Chicago, USA[4] to set up the International Civil Aviation Organization (ICAO)[5] and to debate the legal status of territoriality and rights in air space.[6]

In a historical context, the convention was important for the territorial jurisdiction that it gave each state. The agreement was the second legal document which legislated the rights and responsibilities of foreign aircraft that flew in foreign air space. The first legal document signed in Paris in 1919 was both antiquated and vague. The Chicago agreement[7], however, incorporated both broad principles of

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[4]Conspicious by its absence was the Soviet Union. Among those present were: Afghanistan, Australia, Belgium, Bolivia, Brazil, Canada, Chile, China, Columbia, Costa Rica, Cuba, Checkoslovakia, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, France, Greece, Guatamela, Haiti, Honduras, Iceland, India, Iran, Iraq, Ireland, Lebanon, Liberia, Luxembourg, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Panama, Paraguay, Peru, Phillipine Commonwealth, Poland, Portugal, Spain, Sweden, Switzerland, Syria, Turkey, Union of South Africa, United Kingdom, United States of America, Uruguay, Venezuela, and Yugoslavia. Source: International Civil Aviation Service, Part 1, (London: Her Majesty's Stationary Office, 1964), p. 2.

[5]The delegates agreed that the headquarters of the ICAO would be in Montreal, Canada.

[6]The Chicago Convention is listed as U.N. Document A/4141. The Final Act and Appendix can be obtained from this source: International Civil Aviation Service, Ibid.

[7]See appendix I.

international law (that were to be used in the outer space treaty over thirty years later) and methods of enforcing those laws. It was, in effect, a practical document.

Article 1 of the Chicago Convention gave a state complete sovereignty to the atmospheric space above its territory. It did not give the state any jurisdiction to the area above the atmosphere. This article declared that each state had "complete and exclusive sovereignty over the air space above its territory". The article did not define how far that sovereignty extended and as a result, "sovereignty" became subject to individual interpretation.

> Now that space flight has become possible, considerable speculation has arisen as to precisely what Article 1 means. There are various schools of thought. According to one school, both the Paris and the Chicago Conventions had it in mind only to deal with the activities of aircraft depending for their flight on aerodynamic lift. Therefore, this school says, air space should be interpreted accordingly, and the maximum height up to which States should be permitted to exercise sovereignty would be of the order of 20-25 miles. According to the other school, "air space" must be given its literal meaning, and the scientists must be asked to pronounce at what height "air" ends. This they are loath to do with the degree of precision required by lawyers, and on this view, the upper limit of the air space might be placed anywhere between 500 miles and 10,000 miles above the surface of the earth. All sorts of other limits could be, indeed have been, suggested.[8]

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[8] D.N.H. Johnson, Rights in Air Space, (Manchester: Manchester University Press, 1974) p. 60

Article 2 referred to principles of territory regarding aircraft. "... the territory of a state shall be deemed to be the land areas and territorial waters adjacent thereto under the sovereignty, suzerainty, protection or mandate of such a state."[9] This article gave states the legal right to exercise sovereignty over their land and their territorial waters.

Articles 5 and 6 of the convention set strict rules for aircraft when they flew over another state. In order to fly over nation B, nation A would first have to receive authorization from nation B. This rule was to be strictly enforced by the ICAO because earlier conventions(notably the Paris convention of 1919) had passed resolutions similar in intent to articles 5 and 6 but impossible to enforce because of ambiguities in the wording.

Article 8 made it illegal for a foreign state to fly a pilotless aircraft over another state. Article 9 gave each state the right to prohibit another state from passing over a certain part of its territory if that territory was a military area or an area which might

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[9] It was because of articles 5 and 6 that the Soviet Union refused to adhere to the Chicago Convention. The rights of passage referred only to scheduled international air service and the Russians feared that "charter" or "taxi" airlines with no planned schedule would not have to obtain permission of the state being passed over.

have affected public safety.

Both of these articles enforced the principles of exclusive sovereignty and territoriality that a state may claim over its own area. It is these principles which have been adhered to in conventional air travel since 1944.[10] There remains some doubt that they could be applicable to satellites that fly in air space. These principles (specifically articles 6, 8, and 9) do conflict in some ways with later treaties on outer space. However, the early articles (1 and 2) did establish some rules and regulations which, to a greater or lesser extent, are applicable to the laws of outer space. Later treaties, which would deal specifically with outer space, would incorporate some of the guidelines of the Chicago Convention into their own laws and regulations.

The first U.N. document which was to regulate the conduct of nations in outer space was Resolution 110 in 1947. "This resolution condemned propaganda designed or likely to provoke or encourage any threat to the peace, breach of the peace, or act of aggression."[11]

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[10] Ogunsola Ogunbawno, International Law and Outer Space Activities, (Netherlands: The Hague, 1975), p. 11.

[11] See Appendix II.

The launching of Sputnik I in 1957 prompted Resolution 1148. Article I of the resolution urged "the joint study of an inspection system designed to ensure that the sending of objects through outer space shall be exclusively for peaceful and scientific purposes".[12] In fact this was not to be the case. Both the United States and the Soviet Union had embarked on differing and highly secretive space programs and the resolution had little impact on the space race.

Until the launching of Sputnik I by the Russians in 1957, the Soviet Union had always maintained that there was no limit to the air space above its territory that a state could claim as its own. However, with the launching of Sputnik the Soviet Union reversed its stance and claimed that air space extended only to twenty miles over the sovereign state. This policy shift occurred, obviously, because the Soviets realized that both Sputnik and future operational satellites would have to pass over the territory of other states.[13]

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[12] Ogunsola Ogunbawno, Op Cit., p. 11.

[13] Wyndham Place Trust, Op Cit., p. 98.

In December 1959, the United Nations established a 24-member committee[14] to investigate the Peaceful Uses of Outer Space. This committee (which was increased in size to 28 in 1961) drafted Resolution 1721[15] which enunciated two important principles: 1) that International law, including the Charter of the United Nations, applies to outer space and all celestial bodies and, 2) that outer space and all celestial bodies be free for exploration and use by all states in conformity with international law and that they will not be subject to national appropriation.

> The Committee, bearing in mind that its terms of reference refer exclusively to the peaceful uses of outer space, believes that, with this practice, there may have been initiated the recognition or establishment of a generally accepted rule to the effect that, in princple, outer space is, on conditions of equality, freely available for exploration and use by all in accordance with existing or future international law or agreements.[16]

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[14] The Committee was established and given authority by Resolution 1472 (XIV) of December 12, 1959.

[15] Ogonsola Ogunbawno, Op Cit., p. 12.

[16] A.G. Meyerik (ed), Outer Space, U.N.-U.S.-U.S.S.R. (New York: International Review Service,1960), p. 18.

Resolution 1721[17] was the first treaty to deal specifically with the problems of outer space and the first to emphasize that space was res nulius.[18] The problem was that technological developments in reconnaissance were nullifying the "spirit" that the document had. "Thus, although there (...appeared) to be accord on the fundamental uses of outer space, there (...was) great variance in the interpretation and application of these rules as they affected reconnaissance."[19]

Resolution 1721 reconfirmed the notion that outer space was free for all to use.[20] It recommended that the principles of international law be applied to outer space.[21] It sought more government

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[17] Passed on December 20, 1961.

[18] It should be noted that the term used in the resolution.

[19] Jerome Morenoff, World Peace Through Space Law, (Charlottesville, Va., Mitchie Co., 1967), p. 21.

[20] United Nations, General Assembly, 16th Session, 20 December 1961, Report of the First Committee on International Cooperation in the Peaceful Uses of Outer Space (A/5026), Part A.

[21] Ibid., Part A.

co-operation in space exploration.[22] It recognized the importance of the World Meteorological Organization[23] and the international Telecommunications Union.[24] Finally it recommended that COPUOUS continue its work.[25] All of these principles and recommendations were to play an important part in the final drafting of Outer Space Treaty of 1967.

On December 13, 1963, Resolution 1962 (XVIII) was signed.[26] Parts of this resolution were later to form part of the Outer Space Treaty. The resolution consisted of nine statements which were generally very broad in nature. Part 1 declared that the explor-

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[22] United Nations, General Assembly, 16 th Session, 20 December 1961, Op Cit. Part B.

[23] Ibid. Part C.

[24] Ibid. Part D.

[25] Ibid. Part E.

[26] See Appendix IV.
It should be noted that this resolution was drawn up through an extensive amount of negotiation on the part of many countries. The nine declarations that were claimed in this chapter were the most specific to be agreed up to this point in time.

ation and use of outer space should be in the interest of all mankind. This declaration implied that outer space activities should be peaceful but left room for outer space experiments that were of a military nature. Part 2 dictated that outer space be free for the use of all nations. As was illustrated in later discussions, although outer space was free for all countries to use, it was not accessible to all countries and this was to create problems that are applicable even to today. Part 3 is the key part of this declaration. No country could claim national appropriation in outer space or on celestial bodies such as the moon. This meant that reconnaissance satellites were free to pass over the territory of another state without that state claiming that the satellites were violating its territories.

A number of resolutions were passed prior to the signing of the Outer Space Treaty. Resolution 1884 (XVIII) of October 17, 1963 prohibited the placing of nuclear weapons in outer space.[27] Resolution 2222 (XXI) of December 19,1966 recommended that UNCOPUOS study the implications of space communications and consider other questions relative to outer space.[28] The Nuclear Test Ban Treaty[29] of August 5, 1963

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[27] See Appendix V .

[28] See Appendix VI.

[29] See Appendix VII.

prohibited tests in the atmosphere and made states liable for nuclear fallout from ground tests. These resolutions were for the most part amalgamated into the space treaty. Some of the articles of these first resolutions were incorporated almost word for word into the Outer Space Treaty. But these resolutions might be described as stop-gap agreements at best. The need for a comprehensive treaty on outer space had been known for some time.

The delays in reaching an agreement on outer space were attributable to a number of factors. The Vietnam war was a problem. The number of satellites in the skies were still relatively small (i.e. there was no problem of crowding in space). And the space race to the moon was a major preoccupation for the space programs of both NASA and the Soviet Space Agency. However, the overriding factor for the slow pace of negotiations was neither legal nor political but technical. The sixties witnessed some major advances that were being made in satellite technology and no nation wanted to sign a document that would become antiquated before the end of the decade. At the same time, the need for a treaty which would lay forth the general rules as to how outer space should be governed was becoming increasingly important to them. For these reasons the Outer Space Treaty was signed only ten years after man first projected himself into space.

(2) The Outer Space Treaty

The Outer Space Treaty (OST)[30], was the most important United Nations document that was ever written concerning the governing of man in outer space.[31] The OST is composed of seventeen articles that are written in five languages.[32] Nine statements of agreement appear prior to the articles.[33] Even these general statements elicited considerable legal and political maneuvering. They were important because they set the tone

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[30]The full legal name of the treaty is...TREATY ON PRINCIPLES GOVERNING THE ACTIVITIES OF STATES IN THE EXPLORATION AND USE OF OUTER SPACE, INCLUDING THE MOON AND OTHER CELESTIAL BODIES but for the purposes of simplicity the treaty will be referred to by its more popular title as the Outer Space Treaty.

[31]See Appendix VIII.

[32]Article XVII lists the languages as English, Russian, Chinese, French and Spanish. All texts are deemed to be equally authentic in translation and substance.

[33]The terms of this treaty will be discussed in their present tense.

for the treaty. The states that are party to this treaty are "inspired" by the prospects of "man's entry into outer space". This is the first statement of the OST and it suggests that man views outer space, at least in a limited sense, as an area that can be exploited. The treaty then "realizes" the "common interest of all mankind". To a certain extent this contradicts the intentions of the space treaty because later articles allow space to be used for reconnaissance. The treaty "believes" that outer space exploration should be for all nations regardless of economic or scientific development. It is for this reason that the Bogota declarants[34] refused to become party to the treaty. They felt that the treaty could not be peaceful in its intent when activities in outer space were still largely the domain of a limited number of highly technological countries.[35] The Outer Space Treaty then recalls

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[34]The countries that formed the Bogata declaration are Brazil, Columbia, Congo, Ecuador, Indonesia, Kenya, Uganda, and Zaire. The dilemna that they presented to the Outer Space Treaty will be discussed in detail later in this chapter.

[35]This dispute wil be examined in detail later in this chapter and in chapter III. What is important to remember however, is that most negotiations and treaties up to this point (with the exception of Resolution]962) had often ignored the very real concerns of the smaller nations in the U.N. These nations did not only consist of the co-signers of the Bogata Declaration but included a number of other smaller countries as well.

re-solutions 1962, 1884, and 110.[36] The OST combines the principles and intentions of these three treaties. It does not reject them but it does override them. The signatories state their conviction that the OST is necessary and lay forth the principles to which they have agreed.

Articles I,II, and III form the fundamental principles of outer space law.[37] In article I, outer space is made res communis. This means that outer space, the moon, and all celestial bodies[38] are free from any claim of of sovereignty by any one state. It establishes the basic principle that outer space is, and will always remain, the territory of no one-saate. It establishes the "law of the sea" principle which gives all states equal and free access to outer space. Article I states that outer space will be "free for exploration and use by all states...in accordance with international law ...and on the basis of equality..." This statement had, in essence,

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[36]See Appendix VIII.

[37]Fariborz Nozari, The Law of Outer Space (Stockholm: PA Norstedt and Soners Forlag, 1973), p. 38.

[38]In all parts of the treaty, outer space, the moon and other celestial bodies (e.g. Mars etc.) are all termed as one phrase. In order to prevent redundancy and because their names are of limited importance to this subject, "the moon and other celestial bodies" will not be included in the discussion. The reader should note that when the treaty articles apply to outer space they apply equally to the moon and other celestial bodies.

caused a number of delegates to complain that outer space was already being exploited by the richer nations and that an unequal allocation of benefits was being derived from such exploration. To this end the delegates from the poorer nations argued that experimental resource satellites such as LANDSAT must share their findings with smaller nations. Third World delegates argued that, in keeping with the spirit of OST, the more developed nations must allow some room in their telecommunications satellites for their needs as well. As for the reconnaissance vehicles, article I allows for freedom of outer space but there is little evidence that the larger states (mainly the United States and Russia) are willing to share their information.

Article II provides that no state may claim sovereignty in outer space or any celestial body. This allows for freedom of scientific investigation in outer space and for international co-operation in such investigation. The term sovereignty is not defined although it is assumed to mean the same as sovereigny in international law. This article was later challenged by a number of countries. The intent of the article nevertheless was to allow for the exploration of outer space by any countries and this exploration was not given a specific time period or location. Some countries had argued that this article might allow the larger nations to set up permanent space stations that would perform a variety of functions. Such a station could maintain a long life if kept in geostationary orbit.

> ...one can conclude from Article II of the Treaty that the use of the geostationary orbit by any country putting satellites into it does not give to this country the right to occupy any part of the orbit eternally, since this would be tantamount to national apporopriarion. The rational use of the geostationary orbit can be ensured only through international cooperation and specific agreements between states.[39]

In Article III of the OST, nations would have to conduct activities in outer space according to international law. Again the notion of equality of opportunity is emphsized while the use of outer space as a military zone is dismissed. Any activities in space must be performed "in the interest of maintaining international peace and security". However, this could be interpreted to mean that the presence of anti-ballistic missile satellites can be placed in space because they are not weapons and because they can act as a sort of peace officer for activities on earth.

Article IV prohibits the placing in space of nuclear weapons or any weapons of mass destruction. This article is sometimes referred to as the "no bomb in orbit" provision.[40] Neither individual states, nor

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[39] V.S. Sereschchetin "On the Principle of State Sovereignty in International Space Law" volume 2, 1977, Nicholas Matte (ed) in Annals of Air and Space Law, (Montreal: McGill University Press, 1977), p. 430.

[40] Ogonsola Ogunbawno, Op Cit., p. 91.

groups of states (e.g. the European Space Research Organization) may place nuclear weapons in space. The moon could not be used in any way as a military base and there could be no placing of weapons on the moon. Some delegates expressed reservations about this article[41] because they feared that outer space had not been demilitarized the same way that other celestial bodies were demilitarized. "As to what extent the outer space treaty can be used for military purposes, and as to whether any non-aggressive military function, except the placing of nuclear weapons and other weapons of mass destruction in orbit around the Earth, is admitted in outer space, no clear answer can be given."[42]

Article V is a treaty on the rights of astronauts in space and the guarantee of assistance that they will receive if in distress. This article is a precursor to the Rescue Return Agreement of 1968.

Article VI requires states to "bear international responsibility for national activities in outer space...." This makes nation A responsible for damages that it might inflict on nation B should the satellite happen to fall out of orbit. This principle is reinforced in

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[41]This included some members of NATO.

[42]Fariborz Nozari, Op Cit., p. 41.

article VII.

Article VII is referred to as the "liability for damages" clause. It makes every state "internationally liable for damage to another state party to the treaty". The article does not elaborate on the details of how a state can force another to be liable for damages. In the case of Cosmos 954--the Soviet nuclear-powered satellite that fell into Canadian territory--Canada was forced to launch an expensive clean-up operation but the Soviet Union paid only three million dollars in damages which was one-half of Canada's claim.[43]

Article VIII of the OST gives the state which owns the satellite exclusive jurisdiction and control of that object in space (and the personnel, if any). This has raised some objections by those who claim that this article contradicts rather than complements article VI. No state has the right to claim sovereignty in any part of outer space or on the moon. Article VIII, however, grants jurisdictional rights to the country which owns the satellite or installation. "Once a state establishes an installation on a celestial body, it will undoubtedly make efforts to extend the jurisdiction to a larger area around the installation in order to safegaurd the maximum security of such an installation."[44]

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[43] Canada, Department of External Affairs, Annual Report, (Ottawa: Department of External Affairs, 1980), p. 32.

This argument might be extended to include multi-function space stations.[45] Also, one country might declare that a certain low earth path that its satellite is moving in can be used by no other state.

Article IX reflects the concerns of many delegates that space be kept free of debris and that the earth be kept free of future satellites which could upset the earth's environmental balance. It also aims to promote international cooperation in outer space.

Article X is a "rights of observation" clause that gives foreign countries the right to observe space launching and follow their flight paths. Again, this is a recommended procedure and is not enforceable.

Article XI is an agreement to inform other states "to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities". This is not a binding agreement and states have tended to exercise discretion in their announcements of planned launchings of space objects. Some states had attempted to make this registration compulsory but were unsuccessful in doing so.

Article XII allows installations on celestial bodies to be open to

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[44] Ibid., p. 44.

[45] Multi-function space stations would be defined as orbital space stations, manned or unmanned, which would perform a number of functions such as reconnaissance, weather survey and telecommunications.

inspection by foreign states. This article does not applv in any way to satellites of any kind.

Article XIII makes the provisions of this treaty applicable to international intra-governmental organizations. Articles XIV to XVII deal with strictly administrative agreements such as signatory countries, date of entry into force, and notice of withdrawal.

As of July 1980,[46] the Outer Space Treaty had been signed by 90 nations and ratified by 55.[47] Eleven nations gave notices of accession.[48] All of the countries which have launched satellites or aided in their launchings had signed the declaration.[49]

All in all the OST is a marvel of international cooperation and diplomacy. In only ten years between the launching of the first satellite into outer space and the signing of a space treaty, many nations of

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[46]This is the latest data available to the author.

[47]This includes all the countries of the Bogata declaration who were to reject the treaty one year later.

[48]The countries are Australia, Canada, West Germany, Italy, Japan, the U.K., the U.S. and the U.S.S.R.. China was added to this list in 1977.

[49]This included some of the Third World Nations.

the world, including all technologically advanced ones, were able to sign an agreement on international conduct in outer space. This has led some bodies of opinion such as the Wyndham Place Trust group to observe...

> The rather quick arrival at agreement about the content of International Law as regards air space illustrates how far the nations are prepared to go to cooperate when they can plainly see the dangers of national claims, and when no national interests are already established.[50]

(3) Peaceful Uses of Outer Space: A Problem of Definition

The opening statements of the OST recognizes the need for the peaceful use of outer space. Again article IV states that all celestial bodies shall be used for "peaceful" purposes. Unlike the SALT II treaty, the OST does not contain agreed statements or common understandings as the SALT II treaty does because it is an international treaty and not just a treaty between two nations.[51] If there were a set of common un-

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[50] Wyndham Place Trust, Op Cit., p. 100.

[51] In fact, the majority of bargaining involved the U.S.A. and the U.S.S.R.. Once they had reached agreement it then became the purpose of other countries to ratify the treaty.

derstandings, the word peaceful would have been defined explicitly. As it stands now the word "peaceful"in the OST has evoked differing interpretations from the international community. Among them are: 1) non-aggressive, 2) no military personnel, 3) no hostile potential, 4) strictly civilian personnel and potential, and the like.[52]

This difference in interpretation and, more importantly, expectation of satellite activity in space leads George Robinson of the Smithsonian Institute to conclude;

> ...In terms of scientific research for "peaceful purposes", it is obvious that what is peaceful for one purpose may not be for another, and the problems surrounding verification of an item or activity as peaceful becomes a critical and extremely difficult issue to resolve. In fact, I see no effective legal definition distinguishing between "peaceful" and "hostile or threatening" military space activities until some overt hostile act actually has occurred.[53]

In international law the term "peaceful" is subject to different interpretations. These differing interpretations are significant when considered in terms of the roles and functions of the reconnaissance satellite.

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[52]George S. Robinson, "Militarization and the Space Treaty--Time for a Restatement of "Space Law"," Astronautics and Aeronautics volume 17, #2, (February 1978) p. 28.

[53]Ibid.,

> The problem of the limit between air space and outer space is relevant to the question of the legal status of reconnaissance satellites. The legality of the latter depends on whether "peaceful" means "non-aggressive" or "non-military". If it means "non-military", then the use of reconnaissance satellites is felt (at least by the Soviet Union) to be military activity, and therefore, incompatible with the objectives of mankind in outer space. If it means "non-aggressive", the use of reconnaissance satellites is felt (at least by the United States of America) to be peaceful as long as those observations from outer space do not interfere with activities on earth and in outer space, and are, therefore, not prohibited by International Law. Simply stated, international law does not appear to prohibit observation from outer space. After all, reconnaissance satellites are operating in areas which belong to no one. Their legal status is not different from that of an aircraft or trawler plying outside the territorial waters of another State in order to see what is going on.[54]

The space shuttle exemplifies how two states may hold differing interpretations as to what activities in outer space are peaceful and what activities are not peaceful or hostile. The Pentagon views the space shuttle's missions in space as being peaceful even though some of the operations are of a military nature. The Soviet Union sees the shuttle not only as a military weapon (and therefore non-peaceful) but regards all American reconnaissance satellites as instruments of war.

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[54] Ogunsola Ogunbawno, Op Cit., p. 211.

Again, "non-aggressive" satellites might well include weather satellites but the information they gather can be used as an economic weapon and to a lesser extent as a military one. Even satellites that are used strictly over one's own territory can ultimately be military in nature. For example, the Soviet Union and South Africa are the world's largest producers of gold. Some resource satellites can determine the mineral content of soil. If a satellite was to spot a huge and until then, undiscovered gold deposit in northern Canada, it might give not only Canada but all Western countries a better bargaining position vis-a-vis the acquisition of gold from the USSR. Such an example is extreme but it does point out that, as with air space and outer space, it is difficult to find a clear delineation between military and non-military remote sensors and between the "peaceful" and "non-aggressive" employment of those sensors.

As of yet no state has explicitly made moves to halt remote sensing from space, even if it objects to the OST or did not sign it in the first place.[55] In most cases, the states simply do not have the money or

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[55] It should be noted that there were a number of states that did not sign the Outer Space Treaty in 1967. For various reasons (and principally because they were suspicious of the document in its intent) many states chose to delay their signing of the treaty until 1968. Others did not sign the document until 1980.

technology to "neutralize" the satellites. But some of these states do pose a worrisome problem to scientists, lawyers and politicians throughout the world as those who did not sign the space treaty or recognize its legitimacy may attempt to take "action" in the future against satellites that are passing over its territory. A broad hint that such a scenario might well take place was given by an Argentinian lawyer, Manuel Augusto Ferrer (Jr.), at an International Astronautical Federation meeting in 1977. In discussing a South American plan for employing reconnaissance satellites he stated...

> The underlying State is sovereign in its air and territorial space. Thus, it may regulate or fortuitously forbid an activity carried out in space by someone else. This is a consequence of sovereignty. Just as a state allows free transit through its highways and roads, for being the sovereign therein, it may also regulate the exercise of such jus communicationes by establishing speed limits, etc. Such is the case in teledetection activity by remote sensing. In the exercise of its sovereignty, the underlying state should reserve the right to consent or deny activities in its sovereign space. To act otherwise would imply a general and abstract waive to the exercise of its sovereignty.

This particular philosophy ignores the problem that some reconnaissance satellites must assume orbits that will pass over the entire area of the

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[56] Manuel Augusto Ferrer "Legal Aspects of International Cooperation in Remote Sensing" presented at the Twentieth Colloquium of the International Institute of Space Law of the International Astronautical Federation. (September 21 to October 1, 1977), p. 511.

earth in order to stay functional and effective. Such is the case with the LANDSAT series of experimental satellites. Its cycle around the earth is completed once every eighteen days. In order for it to photograph northern parts of Canada and the Antarctic it must move eastward in a north-south direction. It will inevitably be forced to cross over all of South America, very often at a perigee of less than 32,800 km., which would then be a violation of the Bogata principles.

On May 1, 1960 an American U-2 reconnaissance plane was shot out of the sky as it flew over the eastern fringe of the Soviet Union. Two months later an American RB-47 plane, also on a reconnaissance mission, was shot down by a Soviet fighter jet in the Barents sea, just north of the Soviet Union. Francis Gary Powers survived the U-2 flight and was tried by the Soviet Union and accused of committing espionage. To the surprise of many, the United States made no formal protest of the trial and even went so far as to admit that Powers' flight was conducted with the intent of collecting intelligence.

The RB-47 incident, however, sparked a very different type of reaction from the United States. In this case the RB-47 had been shot down over the high seas in a mass of water that separates Canada from Russia. The United States strongly protested the actions of the Soviets because the plane was flying in international waters as is provided for in international treaties. The protest by the United States was justified because the RB-47 was not flying over Soviet territorial waters. Although the matter was quickly resolved (the pilots were returned to the United States) larger questions concerning territoriality remained. This being the case, does not the state also have the right to eliminate, stop the actions of, or otherwise neutralize any high flying object which it perceives as a threat to its national security? If a commercial plane were to stray into Soviet territory (as they sometimes have), it would create an international outrage if the Soviet Union were to shoot it down. The bringing down of Francis Powers' U-2 plane went beyond both the spirit and legality of international air convention agreements. The Soviets neutralized the U-2 not because it was intentionally flying over Soviet airspace but because it was conducting an act of espionage over Soviet territory. Might this not be a reason for neutralizing objects in outer space? Outer space may be every state's territory but if espionage is the intent, then can the state being spied on not justify its neutralizing of the satellite on the basis of its violating the sovereign rights of that state? The OST does not define what satellites may do. Their purpose(be they either telecommunications or reconnaissance) may be offensive but the OST makes no special provisions for the actions of these satellites. Protecting all satellites does not mean that the satellites can have exclusive authority over all other international agreements. If the satellites violate other agreements does the state have the right then to take action? "What is the difference between espionage (let us accept the term provisionally) carried out by satellites and that engaged in by spies? Where is the peaceful purpose of missile tests, of which we are told every day that they are capable of transporting atomic weapons able to sow death in every corner of the world?"[57]

Even after the OST was well established, the debate on airspace has continued in the American community. Space law experts have in the past argued for a very high limit to territorial air space (160-16,000 km.). Their most modified claims to sovereignty in airspace is 110-160 km. - the lowest perigee that any satellite could achieve without falling back inside the atmosphere. In this regard the Americans and Russians can find room for agreement.[58] But the international community has insisted on playing a significant role in laws pertaining to outer space. Unfortunately, this has led to much disagreement among delegates as to what outer space is and what it is not.

In the view of Professor John Cobb Cooper, outer space must be seen in terms of the physical dynamics to which a satellite is subject.

> In the absence of such new convention, basic legal theories must be re-examined and the practical

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[57] Modesto Seara Vazquez, Op Cit., p. 173.

[58] Wyndham Place Trust, Op Cit., p. 99.

> questions at issue must be understood. In the first place it is obvious that we must agree that there is an upper boundary in space to the territory of the subjacent State. Under no possible theory can it be said that a State can exercise sovereign rights in outer space beyond the region of the earth's attraction. The arguments for State sovereignty in space have always gone back to the proposition that it is both the right and the duty of the State to protect itself and that on no other basis can such protection be considered adequate except that it have the right to control, as part of its territory, those regions above it which, if used by other States, may bring damage and loss to persons and property on the State below. Carrying this old rule to its extreme, the outer boundary of the State cannot be further than the point where the earth's attraction will govern the movement of an object in space so that such an object will "fall" onto the earth.
>
> On the other hand, this boundary cannot be lower than the upper limit of the airspace. The rule of international law--that the territory of the subjacent State includes at least the region above it known as airspace--need not be challenged. In other words, it would appear that the upper boundary of the State's territory lies at a point between the upper limit of the "airspace" and the upper limit of the earth's attraction. Somewhere in this vast intervening region the rights of the State below cease to exist as against other States.[59]

The problem remains that where air space ends is still a critical point of dispute in any discussion of the legality or illegality of a reconnaissance satellite.

Modesto Seara Vazquez applies this definition to air space. "Air space is that part of space subject to the sovereignty of a state.

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[59] John Cobb Cooper, Explorations in Aerospace Law Ivan Vlasic, ed. (Montreal: McGill University Press, 1968), p. 263.

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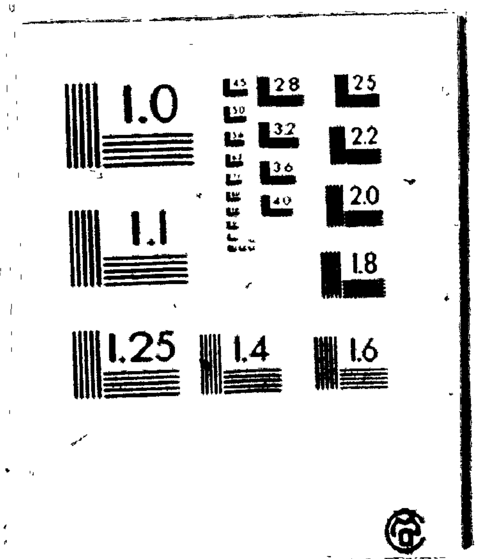

1. The subject of this right of sovereighty is the underlying state. We can draw two statements from this: a) That part of air space directly above the territory of a state is subject to the sovereignty of that state. b) No state may exercise sovereignty over space which is not directly above its territory. 2. The object of sovereignty is the air space above its territory, which appears to be bounded: a) horizontally by a plane which has the territorial frontiers for its boundaries; b) vertically up to a height where the word "air" can no longer be used. In other words, those regions of space where there is no air or atmosphere cannot be called air space."[60]

Vazquez has made a number of assumptions in what separates air space from outer space. In part 1 (a and b) Vazquez declares as sovereign that part of air space directly above the territory of a state. This leaves open the possibility that Side Looking Airborne Radar, as well as satellites could "spy" on a nation from international waters, namely, the seas (as in the RB-47 fiasco) or from its own territory, should the two nations happen to be hostile, or from a neighbouring state that will allow another state to operate within its boundaries. In fact, part b gives specific consent for reconnaissance to take place. Part 2(b) is too vague for practical application. The

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[60] Modesta Sierra Vazquez, Op Cit., p. 27.

word "airspace" can scientifically be applied to the geostationary ring and even at distances further. If by air he means the presence of oxygen, then outer space would begin approximately 11 km. above sea level.

In 1973 the United Nations Secretariat published a paper entitled "Legal Implications of Remote Sensing of the Earth by Satellites". Two main conclusions were derived from the report:

> 1) there does not appear to be any principle or rule of international law that makes it unlawful for a country to freely observe everything and anything in another country so long as it carries out its observations from beyond the limits of national sovereignty;
> 2) the only restrictions are those contained in the obligation to act in accordance with international law and to respect the corresponding interest of other States, as well as the duty to inform the United Nations Secretary General and the public, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of national space activities.[61]

The first point legislates the freedom of action to conduct reconnaissance but at the same time allows for legal retaliation by the country being spied upon by the reconnaissance satellite. The "limits of national sovereignty" is a vague and almost misleading term for there is no territorial determination of what area of air space or outer space is a part

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[61] Jean-Louis Magdelat, "The Major Issues in the Agreed Principles on Remote Sensing" Journal of Space Law volume 9, no. 1 and 2, p. 115.

of one state's national sovereignty. As explained in chapter I, the satellite must often swoop into a low orbit in order to obtain pictures of finer detail of a land area or to collect intelligence of underground installations. Low orbit often means that the satellite will enter the ionosphere or exosphere which are two divisions of the atmosphere. Can a state not claim then that such a perigee is a violation of its national sovereignty?

The second point also holds a number of contentions. Acting "in accordance with international law" is difficult when states have previously chosen to distinguish space law from international law. Respecting the corresponding interests of other states is not a key moral motivation on the part of strategists (be they scientists, lawyers or politicians) who attempt to derive benefits from reconnaissance satellites. Finally, the secretariat states that other states have a "duty to inform the United Nations Secretary General and the public, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of national space activities". This statement is too vague and much too subject to individual interpretation to be enforceable. "The greatest extent feasible and practicable" may be adequate for weather reporting but completely inadequate in reconnaissance.

Although not defined explicitly in any United Nations Treaty or document there is an implied consensus on the boundaries of outer space. Outer space is divided into two sections--outer space and deep space.

Deep space is the easiest of the three territories to define and the one which receives the least attention. This area is generally believed to extend beyond 384,000 km.[62] Deep space is that area which is not affected by the gravitational force of the earth, the moon, or any other celestial body. A satellite placed in deep space would exist in limbo and would not assume any measured orbit.

No resolution on remote sensing would extend to deep space because of the absence of any earth-oriented orbit. At this height, arguments of territoriality would be without purpose as no reconnaissance vehicle could accurately photograph anything on earth and the turnaround time even for radio waves on telecommunications satellites would be too long to render effective the placing of such an object in this area of space. The arguments surrounding outer space and airspace, however, are much more important for it is these areas in which artificial satellites are placed.

Physical scientists have not yet fully determined the boundary delineations between air space and outer space. They agree that air space contains an atmosphere and outer space does not. The problem though is that there is a certain region which contains characteristics of both. The two principal systems of terminology for measuring the different

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[62] Gysbertha Reiznen, Utilization of Outer Space and International Law, (Amsterdam, Elsevier Publishing Co., 1981), p. VII.

regions of the atmosphere are variations in both the temperature and electron density with respect to the changes of altitude.[63]

> It is estimated that the air density falls off by a factor of 10 for each 10 mile increase in height up to approximately 80 miles. Beyond this, the air becomes even less dense thus causing the molecules to be more sparsely distributed. At sea level, the average distance a molecule travels before hitting another molecule is 1/4,000,000 inch; at an altitude of 100 miles, the average distance between collisions is approximately 100 feet. This reduction in the number of collisions with increasing altitudes continues indefinitely, eventually merging with the streams of charged particles and radiation in the regions of the space beyond the atmosphere.[64]

The sharp thermal contrasts in the atmosphere allow scientists to divide it into five distinct levels. They are;

1) the Troposphere--this area extends 11 kilometers from the earth. The temperature reaches -55°C at its height.

2) the Stratosphere--11km. to 30 km. Temperature remains constant at -55°C. The upper portion contains ozone--a sun filtering agent.

3) the Mesosphere--30 km. to 80 km. An increase in temperature occurs as ozone exists in greater quantities.[65]

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[63] James Morenoff, Op Cit., p. 152.

[64] Ibid., p. 152.

[65] The ozone does not extend to all of the Mesophere. Average temperatures are as follows;

Altitude (km.)	Temperature (Celsius)
30	-55
45	+20
55	+20
80	-75

4) the Ionosphere--80 km. to 640 km. Rising temperatures to about 2200°C. Highly charged.

5) the Exosphere--uniform temperature of 2200°C. Weak gravitational pull by the earth. 640 km. to 5000 km.[66]

The problem that international lawyers face is that satellites can in their course of orbit, dip as low as 140 km. or to the area of the ionosphere before they travel back into space towards apogee. The reconnaissance satellite thus follows a path that is both in the atmosphere and outside of it. To add to this confusion some geoscientists have proposed a sixth area of the atmosphere which they term the magnetosphere. This area extends to some 100,000 km. from earth and is the area to which geomagnetic particles will extend.[67]

(4) Outer Space And The Need For A Redefinition Of Sovereignty and Territoriality

The arguments presented so far assume that the reconnaissance satellite does in fact pass over the state being spied upon. This is not necessarily the case. The United States protested vehemently when the

[66] James Morenoff, Op Cit., pp. 153-155.

[67] Ibid., p. 157.

Soviet Union shot down the RB-47 spy plane and attempted to try its pilots according to rules of Soviet justice. The fact is that the American pilots were not near the Soviet boundaries and thus were protected by other law of the sea agreements. However, the purpose of the mission was to obtain intelligence information about the Soviet Union. Therefore the Soviets could have very well claimed that although the flight activities were occurring outside the field of Soviet territorial jurisdiction, the intent of the flight was espionage and the two pilots could thus be tried for having committed such an act. The dilemma here as applied to reconnaissance satellites is that modern reconnaissance cameras with very long focal lengths and very high resolutions can in fact obtain information about another state without ever passing over that state or violating any of the sensed state's legal claims to the territory directly above it. This dilemma will be discussed further in chapter three but the legal problems that surround this product of nature are very diverse.

Although the reconnaissance vehicle is not violating the opposing state's territoriality per se, it can be legitimately accused of violating the sovereign rights of that state. Therefore the state being spied upon might claim that freedom of outer space is secondary to sovereignty. This claim is certainly not without foundation. A number of space law experts such as V.S. Vereshchetein of the USSR Academy of Sciences believe that space law must be based on the respect for the state sovereignty principle. "Sovereign states are principal subjects of international space law as a branch or international public law. They are also parties to all multilateral international agreements in the sphere of space law. Sovereign equality of states is reflected in the universality of these agreements and the absence of compulsory judicial procedure in interpreting the agreements and solving disputes between the parties."[68] Such statements point to the need for sovereignty and territoriality to be redefined in light of the rules of outer space. The "sovereignty" and "territoriality" priciples of international law do not and cannot conform to outer space. The generally agreed upon definitions of sovereignty and territoriality were not formed with outer space in mind and their definitions are applicable to international law but cannot fully be applied to outer space.

Presently, international lawyers are experimenting with redefining the meaning of sovereignty and with applying it to activities of outer space. Here again there is no unified consensus on what sovereignty means. There are a number of differing interpretations of sovereignty and how it relates to international agreements. Stephen Gorove demonstrates that sovereignty can be defined as "supreme authority over people, resources and institutions. In this sense the supreme authority refers both to formal authority as well as to effective control. Jurisdiction is a part

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[68] V.S. Vereshchetin, Op Cit., p. 433.

of formal authority and the exercise of it by a state may normally be traced to or practiced on its sovereignty."[69]

Although this sovereignty may be practiced only within its own territorial borders, a state may choose to assume that a threat outside its borders is still in fact a threat to its own sovereignty and may act accordingly.

> A state's authority over its people, resources and institutions has been the most apparent within its own territorial boundaries including its land, territorial waters and superjacent airspace. However, even beyond their territorial limits, states have not been prevented by and have, in fact, exercised their authority in varying degrees. Examples of this kind come to mind in relation to vessels and aircraft on or over the high seas and the exercise of so-called "sovereign rights" over the continental shelf beyond the territorial waters. The Permanent Court of International Justice in the famous Lotus case noted that the state's exercise of jurisdiction outside of the territorial waters was based on its sovereignty.[70]

The term sovereignty itself is in need of a redefinition. This does not mean that sovereignty as applied to the earth will differ drastically from sovereignty in outer space. It is the rules, not the spirit, which need to be revised.

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[69] Steven Gorove, "Sovereignty and the Law of Outer Space Re-examined" in Annals of Air and Space Law, Mateesco Matte (ed) volume 2, 1977, (Montreal: McGill University Press, 1977), p. 312.

[70] Steven Gorove, Ibid., p. 313.

> The notion of sovereignty has been defined in many ways. In abstract, it represents the authority, beyond challenge, to take decisions and carry out effective action within a given territory. In practice, we tend to relate it to the capacity to promote and protect vital national interests. What we must ask ourselves is: how immune has the notion of sovereignty remained to changes in the international environment? and what is the nature of the changes that have had a particular bearing on it?[71]

The question of territoriality also remains a matter of debate for experts on outer space. Cheng establishes three categories of international law into which territorial control may be divided.

a) national territory--a state exercises exclusive sovereignty e.g. land

b) territorium extra commercium--a territory which cannot form part of a state e.g. the high seas.

c) territorium nullius--a territory not under the sovereignty of any state e.g. Antarctica. 72

In addition to these traditional principles of international law, Cheng chooses to add a fourth category which occurs as a result of the Moon Treaty of 1979.

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[71] K Goldschlag, "The Notion of Sovereignty in an Evolving World System" An address to the Canadian Institute of International Affairs on the Occassion of its Fifthieth Anniversary. (Toronto: Canadian Institute of International Affairs, 1978), p. 4.

[72] Bill Cheng, "The Legal Regime of Airspace and Outer Space: The Boundary Problem Functionalism vs. Spatialism: The Major Premises" in Annals of Air and Space Law, volume 5, 1980, (Montreal: Mc Gill University Press, 1980), p. 337.

d) territorium commune humanitatis--which exists only at the level of treaty law.[73]

International law experts will be forced to redefine territory in terms of outer space. Traditional concepts of territory, as Cheng has enunciated in parts a, b, and c are only vaguely applicable to outer space boundaries. His recommendation that space be declared "territorium commune humanita is", a condition of agreement and bargaining, might be the only solution left in this area. Where territory cannot be clearly established it will have to be assigned. If not, the problem of sovereignty will remain unsolved.

(5) The Bogota Declaration

The most serious challenge to the OST occurred during the period of November to December 1976 in Bogota, Columbia. It was here that eight equatorial countries (Brazil, Columbia, Congo, Ecuador, Indonesia, Kenya, Uganda, and Zaire) met to establish a unified position on the geostationary orbit. Of all the possible orbital paths that satellites can assume the geostationary orbit is the most important. At a distance of 35,800 km. from the earth a satellite moves in the exact path of the earth

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[73] Ibid., p. 337.

(east to west) and travels at the exact rate of speed that the earth turns. Three telecommunications satellites that are strategically located on the geostationary orbit can provide telecommunications to the entire planet. Reconnaissance satellites which monitor weather patterns can take pictures of the earth on the geostationary ring which will analyze and predict weather patterns. Because this ring is necessary for both telecommunications and remote sensing satellites, it is quickly becoming overcrowded.

> Reduced to its bare essentials, the Bogota Declaration asserts that segments of the geostationary orbit (a natural resource) lying above their territories are an "integral part" of the territory over which the equatorial countries exercise complete and exclusive sovereignty. The declaration further states that the devices to be placed permanently on the segment of a geostationary orbit of an equatorial state require "previous and express authorization on the part of the concerned state"; that the equatorial states do not condone existing satellites or the position they occupy on the geostationary orbit; and that the existence of these satellites does not confer any rights of placement of satellites or use of the segments concerned unless expressly authorized by the states exercising sovereignty over the segments.[74]

Among the arguments in support of the Bogota 'declarants' beliefs were that there is no United Nations document or resolution which defines the geostationary orbit as being in fact a part of outer space. To a

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[74] Steven Gorove, "The Geostationary Orbit: Issues of Law and Policy", American Journal of International Law volume 73, (July 1979), p. 450.

certain extent this is true. The Outer Space Treaty does not define the limits of outer space. In their view the geostationary orbit is not covered by the Outer Space Treaty; and the Outer Space Treaty is not a final answer in regard to the status of the geostationary orbit.[75] In later discussions in the UN concerning the Bogota declaration the Columbian delegate stated that the Outer Space Treaty was not binding on the Bogota declarants because no one had signed it.[76] The Bogota declarants' claim to sovereignty in this sphere of the universe was overwhelmingly rejected by countries of various economic and political status. They included Australia, Belgium , Czechoslovakia, France, West Germany, Iran, Italy, Mexico, the Soviet Union, the United Kindom and the United States.[77]

The argument of the United States against the claim by the declarants was that there was no legal or scientific basis for their claims to national jurisdiction over this particular area. Belgium was especially

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[75] Ibid., p. 451.

[76] Ibid., p. 451.

[77] Ibid., p. 452.

angered by the declaration and stated that no countries could claim as their own that which is not occupied. Secondly, it was "absurd" for equatorial countries to claim that the geostationary ring is a natural resource.[78]

The greatest dilemma and most perilous frustration of the Outer Space Treaty is that it does not define nor does it even attempt to define the boundaries of outer space. It was for this reason that the Bogota declaration could not be immediately discounted by anyone in the international legal community. In fact, the Bogota claim that the 35,000 km. zone was not a part of outer space was the first attempt by any country or group of countries to print a numerical delimitation of outer space from air space on a legal document.[79] Until the Bogota declaration, no countries could agree on the region above the earth that would separate the two zones. Although attempts were made to define the limits of outer space prior to the OST they were too varied and too subject to individual interpretation to have brought about an agreement that could be included in the OST. Some countries chose to advocate

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[78] Steven Gorove, "The Geostationary Orbit: Issues of Law and Policy", Op Cit., p. 453.

[79] It should be noted that the Chicago Convention of 1944 did not define or delimit the height of air space above a given territory.

tri-zonal or multizonal delimitations of air space from outer space. Bi-zonal delimitations varied greatly. Proposals put forward included gravitational effect, gravitational control, actual lowest perigee of orbiting satellites, the von Karman line, limit of air flight, limit of air drag, etc.[80] Article II of the Outer Space Treaty prohibited sovereign claims to outer space but did not in fact define what outer space was. For this reason the Bogota declarants stated that the geostationary orbit was not a part of outer space. Because of the lack of definition of outer space the Bogota declarants stated that the OST was not binding on them.[81]

As hostile and repulsive as the Bogota declartion might have seemed to much of the world--including the communist and democratic allies alike--the eight states which constructed the declaration claimed that they were only acting in their own best self-interst. Their fear was not only that satellites hovering over their territory might at some time in the future endanger their own existence but that information could be collected about these states that foreign powers might use to their own advantage.

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[80] Bill Cheng, Op Cit., p. 453.

[81] U.N. Doc. A/AC, 105/p.v. 173 at 56 (1977).

Edward Hudcovic states it this way:

> ...the geostationary orbit contention is a legitimate concern by the Bogota declarants that their sovereign rights with respect to development, control, and use of their natural resources are violated by remote sensing of the earth's resources by satellites within this orbit over their territories. The acquisition of data concerning resources by means of remote sensing satellites and subsequent dissemination of that data is of deep concern to these third world states. Data regarding resources obtained by sensing satellites can provide numerous and useful advantages to those concerned with the exploitation and development of such resources. The Bogota declarants contend that sovereignty extends not only to the physical resources itself, but to information regarding such resources as well. Unrestricted use of resource data obtained from satellites is viewed by thses states as an intrusion upon their territorial sovereignty.[82]

Again, one is brought back to the traditional questions of sovereignty and territoriality. International law has always interpreted these words within the context of the law of the sea and the air. But as already determined the laws of outer space must be interpreted in a different context. And while the majority of nations might agree on what outer space is, their inability to agree on where it is leaves them in a perilous position.

> Both the physics and the law of the Bogota Declaration are open to question. But the mere fact that such a claim can be seriously made by States and that those who consider it unnecessary to delimit outer space from national space are not in a position

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[82] Edward M. Hudcovic., "Remote Sensing by Satellite: Violations of Sovereignty and the Territorial Principle of the Sensed State", in Northrop University Law Journal, volume 1, Issue 1 (Winter 1979), p. 141.

> categorically to refute such a claim because the latter are themselves unable or unwilling to say where outer space begins is merely one of the many chickens of the functionalist and wait-and-see approach which are now coming home to roost. Before it could well be the turn of those States which object to certain types of satellites, such as those that engage in remote sensing, to claim sovereignty over national space above the usual heights at which such satellites orbit so as, not necessarily to exclude them, but to subject them to the consent and control of the States overflown.[83]

The Bogota declaration has been important because of the legal and academic questions that it raises regarding the boundaries of outer space. The overwhelming rejection of the declaration by almost all other countries (including some third world states) has made its chance of gaining support in the United Nations next to impossible. Secondly, the veiled threats of action could not possibly be backed up either now or in the near future. These countries lack the technological expertise to build even airplanes never mind ground-based anti-satellite systems. The majority of them depend heavily on American or Soviet assistance to keep their armies mobile. And their own fragile political infrastructures make their governments vulnerable to internal coup d'etats.

Finally, the Bogota declarants must also concede that the role of satellites in their countries may not be all that detrimental. A query

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[83] Nicholas Matte, "Space Policy Today and Tomorrow" Annals of Air and Space Law Nicholas Matte (ed) volume IV, 1979, (Montreal: McGill University Press, 1979), p. 360.

that the Bogota group of countries (as well as a number of other developing nations) will have to face is whether or not they are prepared to ignore the advantages that foreign-built artificial satellites will provide them. Brazil has already used the LANDSAT satellite to map its Amazon region, a feat that was impossible by low flying aircraft because of the very dense cloud cover which has always characterized this area. Brazil was also a principal co-signer in the Bogota declaration. This obvious contradiction in principles may soon be exercised by other Bogota countries as well.

As it stands now, the Bogota declarants have neither the authority nor the power to change the activities of satellites in outer space. However, their declaration has added fuel to the argument that a clear delimitation of space must be arrived at.

> Even though a state may have prescriptive jurisdiction over a particular person, thing, or event, it does not necessarily follow that the state has jurisdiction to enforce the rule of law prescribed. For example, a state may have jurisdiction to prescribe rules regulating conduct of its citizens in foreign territories but may not have jurisdiction to enforce those rules in personom against its citizens who remain in the foreign territory. A state does not have jurisdiction to enforce a rule of law prescribed by it unless it has jurisdiction to prescribe the rule. Thus, if the Bogota Declaration fails to extend territorial jurisdiction over the geostationary orbit, these eight signatory states would be unable to enforce rules regulating the gathering and dissemination of remote sensing data acquired by satellite. Territorial jurisdiction is lacking, and there would be no legal basis for prescriptive or legislative jurisdiction. If prescriptive jurisdiction is initially lacking state prescribed rules cannot be enforced. "Action by a state in prescribing or enforcing a

> a rule that it does not have jurisdiction to enforce, is a violation of international law." This does not mean that all jurisdiction fails. A state may then attempt to base its jurisdiction on some other theory, the protective theory for example.[84]

(6) Reconnaissance Satellites and SALT II

The second Strategic Arms Limitations Treaty (SALT)[85] was signed on June 18, 1979 by the United States and Soviet Union.[86] The treaty has never become law because it has never been approved by the United States Senate. When the new administration of Ronald Reagan took control of the White House the SALT II principles were revoked. What is important to this thesis is that some of the articles and provisions within the treaty pertained to obtaining information by satellite. This treaty was the first to actually negotiate the conduct of reconnaissance satellites in space and may well serve as a basis for negotiating future space activities.

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[84] Edward M. Hudcovic, Op Cit., p.144.

[85] The treaty was officially entitled "Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Strategic Offensive Arms".

[86] See Appendix IX.

It was the United States that was especially concerned with establishing rules for satellite actvities in the SALT II treaty. Within the period of signing the SALT I treaty (1972) and the signing of SALT II, the Americans had discovered that the Soviets had built additional missile installations above and beyond the agreed upon limits of SALT I. The Americans were anxious in SALT II to ensure that the Soviets would not violate the agreements of this treaty again. The Americans and the Russians both had a vested interest in checking the other's missile installations and an agreement was reached in the treaty that would allow reconnaissance activities to continue.[67]

In the SALT II treaty[87] there are four articles which deal with reconnaissance satellites or "National Technical Means of Verification". These articles have profoundly affected the thrust of activities in outer space.

In article VII (2c), the treaty states that "there shall be no conversion of...space vehicle launchers into ICBM launchers...". This

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[87] Department of State Bulliten, volume 79, number 2028, (Washington, Department of State, July 1979), pp. 23-47.
The SALT II treaty has been reprinted in a number of forms and for purposes of convenience the parpgraphs referred to herein will be identified without a publisher. It is for the reader's information that the above reference has been provided.

statement refers not to satellites but to the launching facilities that would place satellites in orbit. The launchers that place the rocket boosters in space (from which the satellite separates when the rocket has reached orbit) can also be used for the launching of ICBM's. Although this article does not deal with reconnaissance directly it does indicate the multiplicity of uses that a lauching pad has. Missiles deployed on a launching pad also have the ability to strike at satellites in outer space if they are in fact directed to do so. The treaty was ensuring that space vehicle launchers remain primarily for the purposes for which they were originally built--to launch booster rockets into space.

Article IX(1C) states that, "(Each party undertakes not to develop, test, or deploy) systems for placing into Earth orbit nuclear weapons or any other kind of weapons of mass destruction, including fractional orbital missiles". This article repeats, almost word for word, Article IV of the Outer Space Treaty. The article positively prohibits the equipping of satellites with nuclear weapons but it does leave the door open for using satellites for other purposes. Among them are; 1) satellites which contain conventional (non-nuclear) weapons for attack against the enemy on earth, 2) satellites which contain conventional weapons for attack against the enemy in space and, 3) laser equipped satellites. This article represents the seriousness of both sides in developing and deploying satellites in space. Both nations literally gave a green light to developing space-based missile systmes which would change the strategic nuclear balance. More importantly, the lack of a provision which would outline the need to keep outer space as a weapon-free zone indicates the desire and willingness by the two nations to take steps to use outer space at least as a testing ground for new weapons and weapon systems. This treaty did not repudiate the OST in its attempt to keep space safe. But the lack of a statement which would ensure that space not be used as a testing ground for weapons systems indicates that either one nation or both could not accept the principle that space be kept weapons free.

Article XV deals exclusively with national technical means of verification. Paragraph 1 permits the use of national technical means of verification "...in a manner consistent with generally recognized principles of international law." This statement allows for the claim of sovereignty over one's airspace (as was made law in the Chicago Convention of 1944) but not in outer space (as in the treaty of 1967). But the paragraph (and in fact the entire treaty) does not specify what "National Technical Means of Verification" actually means. There is no "agreed statement" and no "common understanding" and although it is assumed that this article refers to reconnaissance satellites, it does not state specifically the type of satellite that can be used. Would a satellite be protected by article XV if it is both a reconnaissance vehicle and a nuclear satellite? Future negotiators will have to consider this question.

Paragraph 2 provides that each party will not interfere with the other's national technical means of verificiation. Again, "interfere" is not explicitly defined but it can be assumed that "interfering" would assume one of two forms. They are; 1) direct interference which would involve the destroying of the satellite by a land-based system or, 2) indirect interference such as covering up a construction facility that would make photographing of the events impossible or by beaming microwaves at the satellite which would alter the satellite's electromagnetic system.

In paragraph 3 each party agrees "not to use deliberate concealment measures which impede verification". Such measures are not specified but they would include the construction of underground missile silos. Attached to the paragraph are two agreed statements and three common understandings. All statements are made to further hinder the possibility that any "cover-up" of military activities might be permitted.

Article XVIII(2C) would establish a Standing Consultative Commission that would enable such a committee to "consider questions involving unintended interference with national technical means of verification, and questions involving unintended impeding of verification by national technical means of compliance with the provisions of this treaty". This statement is an assurance for both parties that remote sensors will not be tampered with. If such a committee were established it would substantially reduce the powers of international bodies such as the United Nations Council on the Peaceful Uses of Outer Space. This might spark some outrage on the part of smaller nations who would view the council as having lost its effectiveness.

If anything, the SALT II agreements can serve as a basis (albeit a fragmented one) for future negotiations on national technical means of verification in particular, and artificial satellites in general. The treaty indicates that closer cooperation in constructing such an agreement is necessary. This cooperation will inevitably mean that both nations will have to define such terms as "national technical means" and "interference". Complicating this effort will be the nagging legal questions of where outer space begins and where air space ends. And no agreement can be reached if done in ignorance of the other countries of the United Nations whose role in the legislation and control of artificial satellites is becoming increasingly important.

(7) The Legal Dilemma of Remote Sensing

The legal arguments surrounding remote sensing are complex and not very well established. Space law did not become a necessity until 1957 when man first projected an object into space. Until that time, international law and international organization concerned itself with debating and disputing boundaries that were clearly defined and clearly visible. Debate concentrated on who would get that which was visible and in short supply. The high seas became res nullius. The airspace above one's land was the exclusive and sovereign right of the nation concerned. Each nation could claim exclusive authority over its territory because it was visible and permanent. Such is not the case with outer space. It is neither visible nor permanent. Its orbits and property characteristics are far above the authority of man.

Strictly speaking no state can claim an area of space as its own because the earth turns. As it turns the state turns with it leaving one area of outer space behind and entering a new sphere. Astronomers have successfully plotted a map of the stars of the universe within which the solar system is moving. A state cannot claim as its own a certain segment of this map because it never stays in one place for even one moment. This is true even of the dipoles which, although not as subject to the forces of rotation, do in fact correspond to the changing tilt of the earth's axis. Any one state's claim, then, to territoriality in outer space can only have legitimacy to that section of outer space in which the orbiting satellite is affected by the gravitational (electromagnetic) forces of the planet earth in general and the territory over the sensed stated in particular.

Remote sensing as defined in this thesis (see previous chapter) establishes a general criterion on which a study of the subject can be based. However, an agreed upon definition of remote sensing in the United Nations has often been characterized by disagreement and political expediency. Throughout the late sixties and seventies a number of proposals were made that would establish a working definition of remote sensing of the earth from outer space. A fixed definition of remote sensing was first established in 1971 but later revised, a move which in part reflected the increasingly accurate technical abilities of reconnaissance satellites.

The May 1971 report of the "United Nations Panel on Remote Sensing Systems of Earth Resources Surveys" suggested that remote sensing be defined as "...a system for measuring environmental conditions at or within a few meters of the surface of the earth by means of airborne and orbital electromagnetic sensors".[88] In 1973 the "General Assembly of the Working Group on Remote Sensing of the Earth by Satellites" proposed a definition as follows "Remote sensing of the earth from space is a methodology to assist in characterizing the nature and condition of the natural resources, natural features and phenomena, and the environment of the earth by means of observations and measurements from space platforms. Specifically, at present, such methods depend upon emission and reflection of electromagnetic radiation."[89]

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[88] Carl O. Christal, "Remote Sensing and International Law" in Annals of Air ans Space Law, Edward Matte (ed) volume 5, (Montreal: McGill University Press, 1980), p. 383.

[89] Ibid., p. 384.

In 1978 a third definition of Remote Sensing was proposed by the Working Group on Remote Sensing. Although more vague in character it was generally accepted as being more functional in application. "The term remote sensing of the earth means remote sensing of the natural resources of the earth's environment."[90] There was a need for a clearer meaning of "remote sensing of the Earth and its environment". In a move to correct this problem the Soviet Union proposed the following.

> The term "remote sensing of the earth from outer space" means observations and measurements of energy and polarization characteristics of self-radiation and reflected radiation of elements of the land, ocean and atmosphere of the earth in different ranges of electromagnetical waves which facilitate the location, description of the nature and temporal variations of natural parameters and phenomena, natural resources of the Earth, the environment as well as anthropogenic objects and formations. [91]

The rational behind the Soviet position was that this definition could include all reconnaissance satellites from weather satellites to ground penetration infra-red satellites to sonar sounding devices. In this way no state could declare that a natural resource satellite could not be

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[90] U.N. Doc. A/AC. 105/218, Annex 3, (13 April 1978), p. 5.

[91] U.N. Doc. A/AC. 105/240, Annex 1, (10 April 1979) , p. 77.

used as a method of gathering intelligence whose ultimate purpose might be military in its intent.

Both definitions have formed a working basis by which remote sensing activities have been discussed. Such a situatuion has allowed Carl Christol to conclude that

> Although the 1978 formulations are less a definition than a genralized description of a functional activity, and although they are less specific than the Working Group's 1973 definition and the 1979 Soviet proposal, the proposed definitional Principle as set forth in 1979 was of some legal significance. It gave support to the legality of remote sensing activities without seeking to identify the precise means to be employed. It assumed that such sensing activities were lawful to the extent that peaceful sensing relates to the natural resources of Earth and its environment. With the acceptance of this basic proposition the way was open for the identification of applicable rights and duties of the legal persons engaging in such sensing. However, the lack of a formally accepted definition has not imposed inhibitions on the lawful sensing activities that were then taking place. Such sensing found support in the relevant provisions of the 1967 Priciples Treaty. It was also supported by the practice of the space-resource States. [92]

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[92] Carl O. Christol, Op Cit., p. 385.

CHAPTER III

THE POLITICAL IMPLICATIONS OF REMOTE SENSORS

In the continuing search for security in this age, man has employed his weapons of technology as a means of defending his particular nation state. The controversy which surrounds the development and deployment of military personnel, equipment, and strategy is not only complex but increasingly important in a day and age when military development becomes not only a necessity but an art. The continuing effort to improve upon this art reflects in part the mentality of a world that would rather regard history as a product of foolish generations then as a continuing cycle of lessons not yet learned.

What is unique about the strategy of war in this age is the presence of weapons which can do irreparable damage to this planet and its people. The nuclear phenomenon has rewritten the definition of war. It has meant that defense of one's country has involved every man, woman and child and that a serious mistake could mean annihilation for a large portion of the earth's peoples.

Another unique concept that the nuclear era has created is the fact that the strategy needed for control of this earth by one people will soon involve the use of weapons and resources which are not of the earth. The use of air for purposes of defense and offense had not become a reality until the early twentieth century. But even during World War I the concept of space, "The Last Frontier" being used as a plavground for man was only dreamed of. The 1960's made that dream a reality and the 1980's has made that reality a dangerous oroblem.

This chapter will examine that problem -- space and the medium by which space will be used as a means of defense -- remote sensing satellites. Remote sensing satellites, or remote sensors as they are called, are part of a huge effort to tap the as of yet untapped resources of the area above the ozonosphere. Space exploration for the purpose of gaining knowledge of other celestial bodies is the area in which man has invested most of his research and development funds. The purposes behind this exploration have been primarily peaceful. This is also true for tele-communications satellites which both preceded the remote sensor and contributed to its development. But both of the above-named projects have provided knowledge for how man can defend his world against his own worst enemy -- himself.

The principal actors in the development and deployment of remote sensors are the United States and the Soviet Union. The United States has the greater advantage in this field. Secondary actors include China, Canada, France, Britian and India to name a few.[1] The purposes for employing these satellites are primarily peaceful but remote sensors

[1] It is these countries that have been most active in this area.

are multifunction instruments. They may photograph world weather patterns to warn of impending hurricanes, tidal waves, etc. But the continuous photographing of weather patterns can also provide information, otherwise unavailable, as to how an adversary's crop may or may not have fulfilled its requirements for that year. This could help to determine price fixing.

As was discussed earlier in the paper, scientists were constrained in their efforts to place efficient reconnaissance satellites in the air in the early 1960's by virtue of the fact that they had not yet understood the principles of orbital physics. Early experiments involved telecommunications satellites because they were easier to develop and their orbits were simply geostationary.Much of the early sixties focused on understanding the behavior of the belts that would sustain satellites in space. It was satellites that discovered the presence of the Van Allen Belt (in 1958) which is a ring of radioactive particles above the earth's atmosphere. Later Apollo[2] missions would equip scientists with the data that would enable them to keep satellites in orbit.

Due mainly to the space missions in the 1960's, the United States commands a superior knowledge of space and space technology which has in a strategic axiom left the Americans both more powerful than, and more vulnerable to the Soviets.

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[2] It was primarily due to Apollo that the United States jumped ahead in satellite development.

> The Soviet Union's space technology remains substantially inferior to that of the U.S. For example, there have been no manned landings on the moon, and the Appollo-Soyuz joint missions have revealed that the state of Soviet space technology--instrumentation, sensors, control systems and lightweight computers--is somewhat primitive. There is general concensus in the United States not only that the present Soviet anti-satellite system cannot threaten the most important U.S. space assets that are in geosynchronous or median orbits, but also that in any future technical arms race between the two countries, the U.S. will command a decisive superiority. For this very reason anti-satellite capabilities which could deny the use of space would be an even greater threat to U.S. security than Soviet security.[3]

The massive military buildup of the 1970's allowed the Soviets to "catch up" with the Americans in the field of remote sensor technology. The Soviets, however, have not come close to the Americans in developing the technology that would allow them to gain parity in this area of research. The reason stems from the fact that much of the Research and Development (R and D) in the United States was carried out not only by NASA and the military but through contracts and sub-contracts that were leased out to key companies in the private sector. Among them were AT&T, Bell and Howell, RCA, Polaroid, and Kodak.[4] These companies produced specific components that enabled the Americans to have faster delivery systems and more sophisticated detection equipment .

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[3] Herbert Scoville and Kosta Tsipis, Can Space Remain a Peaceful Enviroment? Occassional Paper 18, (Cowa, The Stanley Foundation, July 1978), p. 11.

[4] For a breakdown of key industries in this field see: Sandra Hochman, Satellite Spies, (New York, Praegar Press, 1978).

The United States leads the world in the development and deployment of reconnaissance satellites.

> Whereas other methods of verification rely primarily on hard data, reconnaissance and surveillance rely primarily on the physical properties of electromagnetic sensors. Once the characteristics and operating environments of these sensors are understood they can provide less ambiguous information as well as broader coverage than other techniques. This reduction in uncertainty has had considerable importance in reducing American fears of imagined threats and non-existant gaps...[5]

The presence of these satellites has had a dual effect on the arms race; 1) it has (as the above quote suggests) provided the Americans with more concrete evidence concerning Russian military weapons systems and the placement of troops and bases and 2) it has given both the Americans and the Russians more ammunition for bargaining specifics at the arms reductions talks. In fact, the Anti-Ballistic Missile Treaty that was signed in 1972 was due in part to the work of reconnaissance satellites.

> The SALT I ABM treaty could not have been achieved had not satellite reconnaissance been available, and it and future agreements could not remain in effect were such reconnaissance not available for verification. Any threat to these capabilities could doom arms control and result in a rapidly escalating arms race. Interference with such capabilities would not only contravene agreements like the ABM treaty but could immediatly halt any restraint on weapons procurement.[6]

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[5] Ted Greenwood, Op Cit., p.11.

[6] Herbert Scoville and Kosta Tsipis, Op. Cit.

As was discussed in chapter II the role that reconnaissance satellites had played in the SALT II negotiations was important. But as the use of reconnaissance satellites becomes more prevelent in the future, the use of all satellties as actual "weapons of war" may become more likely in the far future. The following section will deviate from the discussion of reconnaissance satellites and will highlight how satellites may be used as weapons in the near and far future. Remote sensing and telecommunications satellites are virtually the only types of satellites that occupy space at present but they may soon be accompanied by other, more "hostile" satellite systems.

(1) Satellites as weapons in Space

The use of armoured satellites for military purposes will involve two key components in the 1980's--satellites tipped with nuclear warheads and laser satellites. Of the two, the deployment of lasers seems the most likely.

> ... advances in technology and rising disenchantment with nuclear weapons (because their catastrophic effects prevent their actual use as a deterrent against nuclear aggression) have made space-borne radiation weapons more interesting. Lasers have been considered as kill mechanisms for use in outer space, because they seem to be technologically feasible and possess certain features that make them a likely candidate for a weapons system.[7]

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[7] Herbert Scoville and Kosta Tsipis, Op Cit., p. 11-12.

The legal questions surrounding the use of these satellites are complex. The American space shuttle Columbia has the capability of placing laser equipped satellites in space and repairing them in orbit. These satellites will be used for "peaceful purposes" but that term remains somewhat ambiguous because the most simple laser satellite could be turned into a laser weapon.

> A laser must have great power and good focusing ability to be an effective weapon. These characteristics, however, are also required by the lasers that NASA intends to use for earthquake prediction and geological studies from orbit. A laser that is a scientific instrument at a distance of 40,000 km. could be perceived as a kill mechanism from range of 100 km. Although the United States and presumeably the Soviet Union as well, have extensive and sophisticated means of observing all space launches and maintaining surveillance of objects in space, it would be particularly difficult to assure that a space vehicle would never in the future approach another space borne object more closely than the agreed upon minimum distance as long as it has the ability to change its orbital characteristics on command.[8]

The arms race in space may someday involve laser weapons. In the meantime, the U.S., the U.S.S.R., and the United Nations will have to face a number of moral and ethical questions concerning the placement of laser weapons in space.

Economic and strategic questions will also have to be examined. How

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[8] Herbert Scoville and Kosta Tsipis, Op Cit., p. 12.

will Europe fare in any such arms race? Will missile destroying lasers be placed over all strategic areas of the world or only over the United States and Soviet Union? Another problem will concern the high technology that will be needed in developing these satellites. In spite of the enormous amount of money that is already being spent on weapons development and the arms race, economists, politicians and military experts will have to calculate whether or not such R and D would eventually be so cost effective as to warrant placing these weapons in space.

> Although much more than a laser is needed for a radiation weapons system operating in orbit around the earth, it is quite possible that both countries (both the U.S. and the U.S.S.R.) could be in a position to emplace these and other such weapon systems in outer space in the next twenty years. Laser weapons would be prohibitively expensive and of questionable effectiveness in an anti-missile defense system, but lasers could be practical in a specialized antisatellite system.[9]

The Americans, however, have already indicated an interest in developing laser weapons systems at least on a small scale basis. Already Congress is attempting to develop programs that would finance research into space-based laser weapons. Martin Marietta, a U.S. high technology company, is being asked to put into space "an operational system of 10 - megawatt/ 10 - meter dia-optic hydrogen-floride lasers by 1983, with 35 laser battle

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[9] Ibid.

stations in the system."[10] Segmented composite material mirrors of the type developed by United Technologies would be useful for beam direction.

Other parties, such as the Canadian government, believe that the United States will be prepared to place anti-satellite systems (it is cautious not to identify which systems) into orbit by the late 1980's. A report which analyzed U.S. space market potential stated:

> Within five to ten years space based systems will constitute the first line of defense for the U.S. against a strategic nuclear weapons attack. A major move is underway to provide systems by the mid to late 1980's that will operate from nuclear hardened satellites to enhance U.S. survivability through improved early warning, ballistic missile and bomber attack assessment and destruction of hostile systems from space.[11]

The Soviet Union apparently views the matter similarly. As mentioned earlier, the Americans can command an advantage over the Soviets partly because American R and D "think tanks" incorporate private industry as well. One is led to believe, therefore, that although the Soviet Union is pursuing R and D into antisatellite weapons, the United States clearly has the advantage.

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[10] "Martin Marietta Stresses Technology in Two Areas", Aviation Week and Space Technology, volume 116, number 8, February 22, 1982, pp. 66-67.

[11] Canada, Canadian Space Industry: Marketing Opportunities In The 1980's, (Ottawa: Department of Industry, Trade and Commerce, 1980)

> The Soviets last week (the week of February 12, 1982) petitioned the United Nations for a treaty banning all weapons in space, singling out the USAF/VOUGHT anti-satellite miniature homing vehicle to be launched by the Mc Donnell Douglas F-15 as a violation of this principle.[12]

Nevertheless the Soviet Union is actively pursuing anti-satellite systems. It has been rumored that the SS-18, one of the most sophisticated weapons systems of the Soviet arsenal, has at least the potential to knock out low altitude American satellite stations in orbit. The problem is that interception in space is still a difficult task.

In terms of anti-missile capability, the Soviet Union is known to be experimenting with satellites that would destroy American missiles that are aimed at destroying Soviet satellites. Such systems are not in place, of course, due to the Outer Space Treaty. But the problem for the Americans as with the Soviets, will be to determine whether satellites deployed in space for peaceful purposes will actually have multifunction capabilities, i.e. capabilities for testing anti-satellite systems.

> ... (the) Soviet Union is operating in low earth orbit an anti-satellite battle station equipped with clusters of infrared-homing guided interceptors that could destroy multiple U.S. spacecraft. THE PODDED MINIATURE ATTACK VEHICLES PROVIDE A NEW USSR CAPABILITY FOR SNEAK ATTACKS ON U.S. SATELLITES. In the past, the Soviets have launched killer satellites to fly past Soviet target

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[12] "Editorial", Aviation Week and Space Technology, volume 112, number 4, August 31, 1981, p. 13.

> spacecraft within one or two revolutions. U.S. early warning satellites and radars then could detect the booster launch and determine from the mechanics that an anti-satellite test was being conducted.[13]

Another key problem that the United States and the Soviet Union may have to face is the vulnerability of satellites to attack.

> Space based systems, either defensive or offensive, cannot be securely protected. Hardening them, deploying decoys, providing a measure of maneuverability, or placing them in orbits that permit several hours warning time of an impending attack can offer a degree of safety by complicating the problems of the attacker. But a determined adversary, willing to undertake the colossal costs associated with space war fighting, can destroy or render ineffective any space platform.[14]

This factor could act as a deterrent against a massive buildup of space based systems. But there is little doubt that both the Americans and the Russians would invest heavily in such systems if they percieved that their satellites (both armed and unarmed) were in real danger of being destroyed.

As chapter II had illustrated, the Outer Space Treaty became the most important treaty on the peaceful use of outer space that has ever been signed. The primary clause, article IV of the treaty, forbade the emplacement of nuclear weapons or any other weapons of mass destruction in space. The moon or any other celestial body (e.g. Mars) could be used

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[13]"Editorial", Aviation Week and Space Technology, volume 112 number 3, August 24, 1981, p. 15.

[14]Herbert Scoville and Kosta Tsipis, Op Cit., pp. 12-13.

only for peaceful purposes. The U.S. and U.S.S.R. complemented this treaty with the Anti-Ballistic Missile (ABM) Treaty in which both countries agreed NOT to interfere with each other's national technical means of verification or their ability to spy on each other via the medium of satellites. However Article IV did not disallow the placement of **anti-satellite** systems in space. They only prohibited their actual use.

There are two problems facing both nations and space law experts alike in using space as a medium for peaceful exploration and development: 1) it is difficult to verify if one nation is in fact using space only for peaceful purposes and 2) it is difficult to differentaite between what activities in space are peaceful and what activities are hostile. Neither the U.S.S.R. nor the U.S. is under any obligation to tell each other in advance what satellites are being placed in space or why they are being used. As a result, both countries must face the enormous task of trying to keep on record every satellite and every piece of debris that exists in space (the count now exceeds 20,000). This is not easy because, as with other Soviet weaponry, there is a much greater amount of secrecy surrounding Soviet space efforts.

The main problem, however, surrounds the definition of what is peaceful and what is hostile. As mentioned earlier, the space shuttle Columbia has been designed and is being used for "peaceful" space exploration. Nevertheless, the fourth mission of the space shuttle Columbia (June 1982) spent two days in space carrying out a top secret Department of Defense "experiment". One would not have too much trouble realizing that the intent of the mission would be anything but peaceful (the Soviets have always maintained that Columbia's purpose is primarily military) and that the experiment is probably concentrating on placing anti-missile or anti-ballistic missile satellites in space. However, in spite of the treaties which may prevent the use of space for military purposes, there is little that can be done until space has been abused.

> In terms of scientific research for "peaceful purposes", it is obvious that what is peaceful for one purpose may not be for another, and the problems surrounding VERIFICATION of an item or activity as peaceful becomes a critical and extremely difficult issue to resolve. In fact, ... (there is) no effective legal definition distinguishing between "peaceful" and "hostile or threatening" military space activities until some overt hostile act actually has occurred.[15]

In a sense, this makes the policing of space an almost impossible task. Future treaties will have to clearly define what activities are hostile and when it is no longer permissible for a satellite equipped with laser ABILITIES to be allowed in space. George S.Robinson voices this concern most accurately:

> It seems to me that a number of statesmen involved in the ongoing development of international cooperation in space, arms control and disarmament negotiations, and the formulation of "new" space law are turning a blind

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[15] George S. Robinson, Militarization and the Outer Space Treaty - Time for a Restatement of "Space Law"" Astronautics and Aeronautics 17(2) (February 1978), p. 28.

> eye to the extension of Earth-bound warfare technology into space and the impact of this militarism on the Outer Space Treaty of 1967.[16]

The decision that both the U.S. and the U.S.S.R. will now have to make is whether or not they are willing to keep space free of any weapons or weapons systems. If they want to do so then their task will be a difficult one. A new Outer Space Treaty, while credible in its intent for keeping space peaceful will have to be revised in light of the arms race that is taking place in space. A new treaty must specify what a satellite can or cannot do and what limitations will be placed on both telecommunications and remote sensing satellties.

If the U.S. and U.S.S.R. decide that space need no longer be kept as a weapons free zone, then the arms race will assume a new dimension that could either deter the threat of nuclear war on earth, or increase its probability.

(2) The Military Options For Canada

Canada's main space partner is the United States: it was NASA which launched all nine Canadian satellites. The close ties between these two countries will no doubt continue to be strengthened because of the technological, cultural, and geographic similarities which both countries share. Both countries are allied members of NATO and both countries form

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[16] *Ibid.*, p.26.

the Northern Air Defense Command--a crucial player for the United States should the two superpowers ever go to war. As a result, both countries share an enormous amount of technological information with each other. This includes information derived by satellites.

In 1969, newly elected Prime Minister Pierre Trudeau commissioned a white paper on Canada's defense policies for the seventies. The White Paper, released in 1971, noted the importance of keeping constant surveillance over Canada's territories. It pointed out that the Canadian Forces at that time were in such a state that they were hardly a formidable force on the world scene. A more updated and integrated role for Canada was advised and surveillance was named as a key component of a restructured Canadian Force. The White Paper also recommended that Canada should have an integrated force which would combine the army, navy, and air force. Updated weapons systems were recommended for all three component parts of the Canadian military.

> It has been possible...to organize Canada's surveillance arrangements so as to make them completely compatible with the needs of collective security. At sea the selection of trade defense as a NATO role is perfectly harmonious with Maritime surveillance for both tasks require continuous observation of the seas off Canada's coasts. The only knotty problem which has to be faced in that respect is whether there is a need for an effective anti-submarine surveillance in the arctic waters. In the air, surveillance of Canada's airspace is an entirely necessary aspect of protecting the security

> of the United States air force nuclear delivery system upon which, together with the U.S. naval ballistic missile submarines is based the entire structure of NATO defence. North American air defences may be redundant in the ballistic missile age, but aerial surveillance is still necessary, and in the future it may be necessary to provide defenses against long-range cruise missiles by maintaining interceptors far enough north to be able to interdict the mother aircraft before they reach launch point.[17]

As a result of the White Paper but more importantly because of the development of aerial surveillance instruments in the seventies and the eighties, Canada more by circumstance than by want, has become a major player in the outer space race. Her vast size has been a problem that has hindered her development as a nation since the beginning. The need for an established communications and remote sensing industry has made Canada one of the largest producers of satellite technology. This technology has led to the development of telecommunications satellites such as the ANIK satellite series.

A number of Canadian companies are involved in the development of telecommunications satellites and remote sensing satellites. While some Canadian companies are producers of satellites, most companies simply produce special parts for larger satellite projects. Most Canadian companies are subcontractors for larger American corporations, the majority of whom

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[17] Nicholas Tracy, Canada's Foreign Policy Objectives and Canadian Security Arrangements in the North, Operational Research and Analysis Establishment, (Ottawa: Department of National Defense, 1980), p. 55.

have contracts with NASA. Nevertheless their presence is felt in the international satellite industry and their technological expertise alone could enhance Canada's role in the arms race in space.

Among the most proficient producers of satellites and satellite components are Canadair, Fleet and Control Data. The Canadair CL-215 Multi-purpose Aircraft can perform a number of surveillance functions including maritime surveillance. Of the surveillance systems there are three that fit the needs of the military: the CL-89, CL-289, and the CL-227. The CL-89 is used in the West German and British Armed Forces. It uses infrared and advanced line scan sensors. The CL-289, a modification of the CL-89, is being used by the West German and American military. Both are mid-air retrieval cameras. The CL-227 is a remotely piloted vehicle that can take off and land via remote control. It too uses infrared techniques. None of these sensors however are space based.[18]

Fleet Industries, a division of Ronyx Corporation, produces both commercial and military satellites. They have been involved in the production af the Anik C, Anik D, and Landsat among others. Control Data produces strictly military satellites and specializes in perimeter surveillance sensors.[19]

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[18] Canada, Canadian Space Industry, Op Cit., pp. 20-23.

[19] Ibid., pp. 34-57.

These companies spearhead the drive for Canadian companies to become a part of the lucrative American satellite market. For the near future at least, Canadian industries will become more competitive in the bid for NASA and other American military contracts. The Defense Production Sharing Agreement will allow Canadian companies to grow in this field. But Canada also produces much of its own equipment for communications and remote sensing technology and at least has the potential for producing artificial satellites that will be able to spy on the Soviet Union.

The far future (the 1990's and beyond) leaves many unanswered questions for the role of Canadian industry in the development of remote sensing satellites. Part of this thesis will maintain that the role of Canadian industry will become increasingly important as the arms race continues and as the buildup of arms in outer space continues.

The 1980's will see a decade of expansion into outer space. Canada has the opportunity of becoming a part of that arms race. In all probability she will become a significant factor because of the dependence of her high technology industries on the U.S. for contracts in this field. The one question for Canada will be whether or not she should contribute independently to the arms race in space and whether or not she can risk such a venture. If Canada were to separately survey the activities of the Soviet

Union it would mean that Ottawa would be developing a more aggressive defense policy vis-a-vis the United States and NATO (which views Canada as a satellite of the United States) than heretofore. Such aggressiveness is not likely to occur. A more probable scenario would involve the building of remote sensors for countries outside of the U.S. This has already occurred on a small scale with the buildup of the Canadair CL-89 and CL-289 series. With proper investment Canada can become one of the principal suppliers of remote sensor technology not only to NATO allies but non-NATO allies as well. Such tactical moves would place Canada in a prominent position in defense circles but might seriously damage her credibility as a neutralist power in international politics.

The presence of remote sensors over Canadian soil has been for the most part a peaceful effort on the part of Canadians to live with if not conquer the vast Canadian landscape. The majority of remote sensors are used in environment related missions. These include soil analysis, mineral exploration, and seismological research. The purpose of these sensors is primarily to obtain data to be used in environmental planning and industrial investment. How Canada is developing the capability of using the information that she is gathering by remote sensing techniques to aid in defense of North America and in gathering intelligence on Soviet activities is a question that she has not fully answered.

The conclusion is that much of what happens in the future will concern the attitude of the federal government in Ottawa. Canada's intelligence gathering information vis-a-vis the Soviet Union is now intricately bound up in American military activity. Before Canada does pursue an independent line of defense policy serious consideration must be given as to the benefits and risks in becoming less dependent on the U.S.. The lucrative contracts that Canada has been able to aquire because of the DPSA would diminish and a "breaking away" by Canada from her traditional military posture might affect Canada's trade relations with the Americans in general for which a dominance-dependence relationship exists on the part of the United States towards Canada. What remains clear is that Canada has the potential to become a world leader in the field of remote sensor technology. But if Canada lacks American investment, and more importantly, American approval of her defense activities, then Canada could stand to lose more than she could ever gain.

Because Canada is only a mid-sized country, her role in the deployment of reconnaissance satellites must be tied in with 1) her concept as a high technology producer for this decade, and 2) her own perception of herself as a sovereign state in this world. Canada's reliance on the U.S. for her defense needs has allowed Canada to enjoy some of the benefits of being a member of NATO and NORAD. The strength of her neighbour to the south has given Canada all the security she needs for a common defense of her own border. This attitude has been challenged lately by the Reagan administration. Canada's role in the Defense of NATO must be increased, the new administration argues. Indeed, the proportion of GNP that is spent on defense in this country was only the sixth largest of any country in NATO in 1981.[20] If Canada has the technical capabilities to build reconnaissance satellites does she or should she have the military fortitude to deploy them?

This issue was spoken to by the Interdepartmental Task Force on Surveillance Satellites. Released in 1977, the Task Force report identified "surveillance" in this way; "Within the narrowest concept of sovereignty control, surveillance can be defined as the detection and observation of human intervention in whatever form it might take within the region of concern".[21] The report recommended that satellites be deployed to aid in Canada's protection of herself, to aid in gaining knowledge of her environment and ecology, and to create revenue by leasing the satellite services to other countries. The report identified six features of surveillance by satellite that placed it above any other type of aerial or ground surveillance. They are:

1) Completeness - in continuity of coverage at synoptic scales.

2) Accuracy - in location of detected targets in the vicinity of ground control points.

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[20] International Institute for Strategic Studies, The Military Balance 1981-1982, (London, International Institute for Strategic Studies, 1981), pp. 22-39.

[21] Interdepartmental Task Force on Surveillance Satellites, Satellites and Sovereignty, (Ottawa: Energy, Mines, and Resources, 1977), p. 7.

3) Reliability - operates in all weather, day or night.

4) Timeliness - data can be received and processed in close to real time.

5) Repeatability - fixed radar beam geometry relative to the earth's surface, and satellite passes that repeat over any point at constant sum angle, ensure repeatability for radar sensors but also for optical sensors.

6) Cost - using systems dedicated solely to simple detection and location of relatively large targets and to monitoring environmental factors, the total cost of satellites over 15 years would be only one-tenth that of aircraft for the same frequency of wide area coverage. Also, costs could be shared with other nations.[22]

The report also identified four negative features of surveillance satellites:

1) Resolution - an altitude of 800 km. places stringent limits on the ability of any sensor compared with typical aircraft altitudes, with the exception of synthetic aperture radars where resolution is independent of range.

2) Signal Processing - covering a large area, even with moderate resolution, places severe demands on recording and processing technologies.

3) Data Handling, Analysis and Dissemination - the high rates for satellites will place strains on man's ability to analyze and interpret the data, and

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[22] Ibid., p. 10.

place large demands on broadband communications facilities for dissemination.

4) Satellite Launch - Canada must rely on another nation to launch its satellites.[23]

On balance, however, the Task Force did recommend that satellites should be deployed as the benefits would outweigh the costs.

Canada does in fact possess a surveillance capability which is independent of any other country including the United States. The Task Force noted that an option for Canada in the SEASAT - A program was to operate the surveillance satellite without any help from any country. The only prohibitive problem at present, it would seem, is that, as already explained, Canada lacks adequate launching capabilities. This does not mean that the construction of such facilities would be so costly that they would be cost ineffective. When structured in with all the costs of operating a Canadian surveillance satellite system without international participation as opposed to operating with international participation, the costs would differ by only some 43 million dollars.[24] This is actually a small sum when one considers the enormous technical and financial benefits that could be derived if such an option were pursued (there would of course be some risks as outlined in scenario three of this chapter).

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[23] Ibid., p. 11.

[24] According to a report the total capital costs for a Canadian satellite International participation would be 263 Million and with International participation would be 180 million. Source: See footnote 25 this chapter.

In total, the Canadian government plans to spend 475.8 million dollars on space programs between 1981 and 1985.[25] Of this sum, a total of 135.7 million will be spent on remote sensing. Other areas include the communications program, space science, technology development, and maintaining scientific links with the European Space Agency. Most of the money will be designated for resource management, territorial, and environmental surveillance.[26] The relationship between this 135.7 million dollar investment in remote sensing and the military benefits that might be derived from this investment has not been fully explained by the federal government. It is known that 18.1 million of the 103.6 million being alloted for the communications program is being used to aid in military and navigation programs.[27]

What is certain is that Canada is one of the few countries in the world with a prime contractor capability for satellites and satellite parts (i.e. remote sensing satellites). It is one of the few countries in the world with the industrial capacity and scientific expertise that is required to design and build complete satellites. Secondly, Canada is in a good position to produce if not deploy reconnaissance satellites because of the rift that has been developing between Washington and Western Europe since the beginning of the decade.

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[25] Canada, The Canadian Space Program for 1982/83 - 1984/85, (Ottawa: Minister of State for Science and Technology, 1981), p. 8.

[26] Ibid., p. 8.

[27] Ibid.,

> It would also appear that certain nations are becoming increasingly uneasy about their dependence on U.S. surveillance satellites and monitoring services. The French have already announced plans to launch their own satellites in 1983, and ESA has begun a three year, 11 million dollar prepatory study of two earth observation satellites for launching in the mid-1980's. Developing nations are equally becoming aware of the benefits of satellite based surveillance and monitoring systems.[28]

Although the Task Force recommended that Canada use her capabilities only for her own land and waters, the alienation that Europeans have begun to feel about the U.S. may prompt Canada to seek closer ties with her NATO European allies. This has already begun to happen as the above quote suggests. But this rift has not yet emerged very clearly in the defense sector.

In general, however, any move by Canada to strengthen the surveillance of her territorial boundaries by remote sensing would be welcomed by the U.S. The satellite to be deployed could be a polar orbiting satellite and at 72 N would infringe upon only the uppermost part of Russian territory but would provide continuous coverage of the polar icecap. This would be beneficial to NORAD and the collective security of North America.

How far can or should Canadian sovereignty in outer space extend? This question might best be answered with the reply: How far can American sovereignty extend into Canada? It seems that Canada is willing to forfeit

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[28] Canada, Canadian Space Industry, Op Cit., p. 79.

her sovereignty for the integrity of the NATO/NORAD alliance. For Canada, security is more important than sovereignty. Continental integrity (i.e. the common defense of North America) must take precedence over territorial integrity (i.e. the specific defense of Canada alone). Canada's military role in outer space (as with land, sea, and air) is inseparable from America's strategic interests. What Canada can accomplish by maintaining a separate reconnaissance presence in outer space is that she can donate separately to the common defense of her borders instead of only jointly to that defense. Continental integrity and territorial integrity are not mutually exclusive.

The Task Force report suggested that being more independant in the area of surveillance was not only possible , but desireable. In fact, the report had repeated this assertion a number of times. Canada has begun to adopt the principles of the report in small part. The Canadian government has made it easier for companies that specialize in the development of remote sensing equipment to market their products and services. This has been done through easing tax restrictions and by the government assissting Canadian companies to sell their products by the government using its own influence to lobby foreign interests. However, the federal government has not yet developed a policy that will appease the question of sovereignty and the specific questions that reconnaissance satellites pose. Admittedly, the Task Force report had not spoken to this issue directly.

(3) Present and Future Capabilities in Satellite Development

With reconnaissance satellites specifically, and all space technology generally, the United States holds a commanding lead over the Soviets. It would be erroneous to state however, that Soviet capabilities in space should be written off for the rest of the century. The Soviets were well behind the Americans in the arms race on earth in the sixties but they emerged with a decisive strategic advantage in the seventies. One should note the statement of President Andropov that Russian technological efforts must now concentrate on improving Russian defense via the medium of outer space.[29]

Generally, the Americans will continue to be stronger in all aspects of space technology. Tables X, XI, and XII indicate that the Americans were the first to develop military satellites and that those satellites had a longer lifetime and more advanced capabilities than the Russians now have. The Russians have had to deploy more satellites and their satellites have had a shorter orbital lifetime and a simpler design. In some areas of satellite reconnaissance the Russians are as much as five years behind the Americans.

It is true that for the near term at least, the possibilities of weapons being placed into space are small. The current emphasis in both

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[29] Gerald Utting, "Shoot For the Stars, Andropov Urges Soviets", Toronto Star, 5 December 1982, p. A16.

the Soviet Union and the United States has been to reconstruct ground-based forces and to increase the production and deployment of nuclear weapons. But the present role of reconnaissance satellites may provide an incentive to the Americans or more probably the Russians to divert military funds away from the nuclear arena and into outer space, especially if a weapons reduction accord is signed within the decade. This suggests that both the Americans and the Russians may want to limit ground, sea, and air based military advancement so that they might pursue the development of weapons in outer space where, once again, both sides may attempt to achieve a new "strategic" advantage.

That reconnaissance satellites occupy a unique position in the arms race can hardly be disputed. But it is their function as a "verifier" of enemy activities which not only places these satellites in strategic jeopardy but also creates an incentive for both sides to develop ways of neutralizing them especially if a large scale conflict does occur. The Americans have much to fear if the Russians' interest in developing anti-satellite weapons because the American satellites are becoming multi-function instruments which provide a variety of services such as reconnaissance, ocean navigation, and telecommunications.

In the fictitious but highly publicized account of a future nuclear war, General Sir John Hackett in his book <u>The Third World War</u> writes of the enormous setbacks that the Americans suffered when their reconnaissance satellites were destroyed by the Soviets. "The sudden removal of large areas of satellite surveillance cover, however, was to be much more accutely felt than the reduced communications capability".[30] Hackett's contention is that the communications functions could still proceed but that the loss of information about troop formations could not be recouped. Subsequently, in this fictitious account, reconnaissance satellites that had been destroyed by the Soviets were immediately replaced whereas tele-communications satellites received little priority as communications could still be carried out using the natural spheres of the earth.[30]

The Pentagon's Defense Support Program operates three code 647 satellites in geostationary orbits that are outfitted with infrared sensors to detect the firing of Soviet rockets. The single satellite over the eastern hemisphere would give the U.S. about half an hour's warning time if the Soviets were to launch their land based missiles. The other two, hovering high above the western hemisphere - one over the Atlantic and one over the Pacific - would provide less than fifteen minutes warning time of an impending attack.[31] If these satellites were destroyed before the Russians had fired any rockets towards the U.S., then the U.S. would be at a strategic

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[30] General Sir John Hackett, et al., The Third World War., (London: Sidgwick and Jackson, 1978), p. 180.

[31] "Living With Mega Death", Time, 29 March, 1982, volume 119, number 13, p. 29.

disadvantage. There are a number of reconnaissance satellites operating at lower orbits but information as to the firing of Soviet missiles is not always readily available and even if it was, the transmission of the data and processing of the information might be too slow for analysis.

Still, firing a missile at a satellite in outer space also involves considerable risk. In 1978 it was predicted that it would take the Soviets six to eight hours to reach an American satellite in geostationary orbit.[32] Although this prediction was made some years ago, it might point to the fact that both sides are not anxious to deploy ground-based anti-satellite systems. Such systems would be vulnerable to attack and their effectiveness might be brought into question in any case. If it has been very difficult to strike a geostationary target; how more difficult would it be to strike a satellite which travels closer to earth but at a speed of up to ten km./sec.?

There are conflicting opinions on the abilities of the superpowers to neutralize the satellites that are presently in outer space. Any satellite intended for arms control monitoring must have sensors operating in the infrared band.[33] Photographic infrared coverage can see through camouflage while thermal infrared assists in night-time detection and emphasises objects such as smokestacks and engines. These satellites also

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[32] Stockholm International Peace Research Institute, Op Cit., p. 114.

[33] There is a trend at present towards utilizing cosmic rays as sensors but the point that is being made remains the same, regardless of the band of radiation that is being used.

become vulnerable to enemy neutralization. Infrared operates through the sensing of heat wavelengths of energy (see pp. 29-31) and it is easy for an enemy to discharge radio waves that will scramble these wavelengths of infrared energy and render useless the data that it sends back to earth. This is a less costly, yet more effective way of neutralizing a reconnaissance satellite to the building of ground-based or space-based anti-satellite systems. However, the October 1981 issue of Aviation Week and Space Technology reports that the Soviets are determined to build anti-satellite weapons in space in spite of the prohibitive costs involved in the development of such a system and the enormous technical, legal, and political barriers that would have to be overcome.

> The Soviet Union is operating in low earth orbit an anti-satellite battle station with clusters of infrared- homing guided interceptors that could destroy multiple U.S. spacecraft. The podded miniature attack vehicles provide a new U.S.S.R. capability for sneak attacks on U.S. satellites.[34]

This brings the concept of a war in space much closer in time and raises ethical questions as to how far man should go in the defense of his territory. Will war someday be fought solely in outer space and what effect will this have on the arms race? There is already some concern about crowding in outer space. This will be discussed shortly.

The Reagan administration is known to favour the concept of a

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[34] "Editorial", Aviation Week and Space Technology, volume 115, number 17, October 26, 1981, p. 15.

weapons system for outer space but future American Administrations may not share the belief that outer space could or should be used as a battleground for mankind.

The conclusions to be drawn here are that the possibilities for the deployment of anti-satellite, laser, and even nuclear tipped satellites in outer space will depend mainly on the pace of the arms race in the coming two decades. The technological problems can be overcome but the political ramifications of such systems may be harder to justify to a world which has become unconvinced that the arms race is in fact necessary. As Chapter II has indicated, the decision to deploy weapons of mass destruction in space will not only come under the exclusive jurisdiction of the superpowers but smaller nations as well who have already voiced concern over the legal and moral implications of the satellite dilemma.

Smaller nations do not have the financial resources at present to deploy their own remote sensors. As a result, they are both dependent upon and vulnerable to, the high technology remote sensing abilities of the more powerful nations. These nations only have limited ways and means by which they may deal with this problem. The following section will examine in a game theoretical context, some of the options that are open to both the small nations and to Canada.

(4) Gaming Reconnaissance Satellites: Strategies and Outcomes

Game theory is the formal study of rational decisions. It is used by military strategists because it examines how one entity will behave under every possible circumstance in a military confrontation. Reconnaissance satellites are applicable to any number of gaming situations but for purposes of brevity and simplicity the two types of games that will be studied in this section will be the two person zero-sum game and the n-person non-constant sum game whose strategies and outcomes are more difficult to predict.

As was discussed in Chapter II, the U.S. and U.S.S.R. are, more often than not, partners in their treatment of reconnaissance satellites. They may use them against each other but they tend to present a common front in the international arena, i.e., they both maintain that outer space should be res communis. This has often placed them in opposition to the smaller nations of the world, specifically the non-aligned nations who fear that the passage of these satellites over their territory is a threat to their sovereignty. Politics, ultimately, decides any problem. The United Nations is firstly a political body and only secondly a diplomatic one. Much of the reason for discontent in international circles is the fact that much of the world has little say in how reconnaissance satellites should be allowed to operate in outer space. Ecuador is a case in point. Ecuador was one of the cosigners of the Bogata declaration. It had made its objections known concerning reconnaissance satellites passing over its territories at the United Nations. It might be argued that reconnaissance satellites could only aquire a limited amount of information about this country which would be of military importance. This country is relatively small in size (283,000 sq. km.), and is largely underdeveloped. It has one of the poorest standards of living in the world (per capita income of less than $200 per person in 1981)[35] and its government is both friendly to, and in need of support from both superpowers. Aside from gaining information on roads, mineral resources, and vegetation, it might be argued that there is little information that any superpower could use against Ecuador that would actually threaten its security and sovereignty. How then are its rights being infringed upon? There is little chance that any power could take it over because of its awkward proximity in relation to the U.S. and U.S.S.R. not to mention the international repercussions that would result. Yet Ecuador insists that reconnaissance satellites are a threat to its sovereignty and that they are a serious infringement upon its rights as a nation. To a certain extent, Ecuador is correct in making this claim. Chapter II of this thesis has examined the question of sovereignty in detail. The conclusions that were drawn focussed on how the presence of satellites over foreign territory

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[35]Ecuador is one of the world's poorest countries.

was not illegal but neither was the destabilizing or neutralizing of these satellites illegal. Scenario #1 will focus on the strategies that Ecuador may pursue in its attempts to stop reconnaissance satellites from passing over its territory. This scenario will be examined via the two person zero-sum game strategy. This type of a game allows for payoffs to occur for both sides but is made to work such that one side will clearly emerge as the victor.

Scenario # 1

Problem: Ecuador insists that American and Soviet satellites should not cross its path. Americans and Soviets reply that their satellites must cross over Ecuador in order to remain functional and that space is res communis. In a two person zero-sum game only one player can win. Although simplified, this gaming strategy can be applied to the conflict between Ecuador and the US/SU. This game will be examined using an arbitrarily asigned value of -10 to +10. 0 will represent no change in outcome.

Strategies for Ecuador	Outcomes	
1) continue to protest at the U.N.	-nil	0
2) neutralize the satellite	-stop reconnaissance	+10
	-lose monetary support from both superpowers.	-10
	-create an international crisis.	-10
3) do nothing	-nil	

In all probability, satellites will continue to pass over Ecuador's territory. Ecuador's best option is option one which, if pursued diplomatically may effect some change. Ecuador must realize that its protests can only be effective if they are voiced in conjunction with other states that hold similar views. Thus, Ecuador must attempt to minimize its dilemma. That is the only strategy that is left for it. This would change the character of the game from a two person zero-sum to a n-person zero sum.

Strategies for Ecuador	Outcomes	
1) Ecuador organizes other countries to protest the presence of satellites over their territories.	-no change--problem remains	0
	or	
	-Increases the pressure on the Soviet Union and the United States to remove the satellites from their territories.	+10

The options for the non aligned nations in this game are:

Strategies for Non-aligned	Outcomes	
1) Support the actions of Ecuador	1) will increase pressure on US/SU to be more responsible in outer space.	+5
	2)will worsen the relationship with US/SU on whom they depend for economic aid.	-10
2) Support the position of the US/SU	1)opposite of above	-5
	2)opposite of above	+10

From the choices presented above, nonaligned countries are in a no-win situation. A diplomatic route that they might wish to follow is to moderately support the demands of Ecuador while insisting that the US/SU be allowed to continue in surveillance functions. Non-aligned nations have both benefitted and lost in this game but the payoff for them is zero. The scenario again becomes a two person zero-sum game as the non-aligned best option is to not get involved in the debate.

In the conflict with Ecuador, the United States has a limited number of options open to it:

Options for US/SU	Outcomes	
1) re-route or redirect satellites so that they do not pass over this territory.	1) reduced ability to aquire military information.	-10
2) bargain concessions with Ecuador and promise that the information that is obtained about that country will be passed on to it.	1) satellites will remain over area and info may still collected.	+10
3) do nothing.	1) the US/SU must be prepared to accept that their satellites may be neutralized at some point in the future.	+5
	2) The US/SU may continue to collect information about themselves and each other.	+10

The best option for the US/SU is to pursue option three above while the best option for Ecuador is to pursue option one (two pages previous). For this game the US/SU retains a clear advantage and reconnaissance satellites will continue to pass over Ecuador in the near future. Ecuador will be almost powerless to stop these activities.[36]

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[36] For a detailed examination of zero sum games see: T.C. Schelling, " What is Game Theory?" Contemporary Political Analysis, edited by James C. Charlesworth, (New York: The Free Press, 1967), pp. 212 - 224.

Scenario #2

When and where does outer space become res communis? How far do the rights of a nation extend to in outer space? As discussed in Chapter II, a technical problem with extending sovereignty to the air and beyond is that the earth is not flat but round. As illustrated below, the territoriality of one state cannot ideally be disputed by another state. This is exemplified in Diagram I.

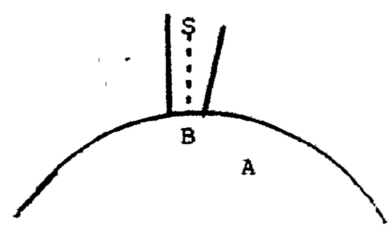

Diagram I

However, an object may remain over its own territory yet it can aquire information about an enemy territory as well. This is illustrated in Diagram II.

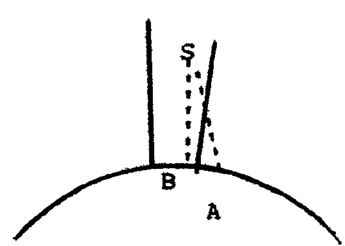

Diagram II

Although the satellite belongs to nation "B" and is operating within its own territory, it also is in a position to spy on nation "A". Is the satellite in nation "B" violating the territorial rights of nation "A"? If this is so, is nation A justified in taking retaliatory action against the satellite which is geostationed over nation B?

> What is true of reconnaissance by ships and by aircraft applies equally to reconnaissance, as such, by satellites. Whether such reconnaissance is lawful or not under international law depends, therefore, in the first instance on whether the reconnaissance is within the territory of the state under observation or is outside of it. This will depend in turn on the height to which a state's sovereignty over the airspace above its territory is said to extend.[37]

The scenario presented here is intended to act as an antecedent to scenario #1. In this scenario the reconnaissance satellite could be a geostationary satellite which does not move within the territorial boundaries of the other nation.

Problem: a satellite hovering over nation B is collecting information about nation A that may be jeopardising the security position of nation A.

Strategies for A	Outcomes	
1) Do nothing.	- espionage may continue indefinitely. Security interests will be further jeopardised.	-5
2) Neutralize.	-espionage will stop.	+10
	-distrust will increase.	-10
	-no satellite is safe..	-10
3) Protest at U.N.	- limited concessions may be made.	+5,-5

The scenario presented here cannot simply be referred to as a zero-sum game for there is no clear no clear winner or loser. One side's loss is not the other side's gain. This scenario reflects a two person non-constant sum game for there is no clear winner or loser in the conflict.

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[37]Martin Shubik "The Uses of Game Theory" Contemporary Political Analysis ed. by James C. Charlesworth, (London, Free Press, 1967), pp. 249 - 250.

There is room however, for a joint payoff to occur between nations A and B. Nation B could either concede to nation A and lose its ability to collect information from nation A, or it could agree to release the information that it collects about nation A to nation A. In either case it is in a minority position.

Problem: A reconnaissance satellite belonging to nation B is spying on nation A and has its satellite neutralized by nation A even though the satellite is hovering over nation B.

Options for B	Outcomes	
1) Do nothing.	-Nation B loses its data collection capabilities.	-10
2) Place a new satellite in space to replace the disabled one.	-High probability that nation A will repeat its action.	0
3) Protest at the U.N.	create a debate about the incident.	0

The OST is designed so that there is no guarantee that space is res communis. To date, the forces prohibiting nation A from committing such an act are not legal but, rather, technical. Most countries have not yet developed the capabilities to neutralize satellites even in low orbits. Thus, there is a continuing need for the international community to negotiate a treaty which speaks directly to the issue of the legal status of satellites in outer space and what they are prohibited from doing, even in their own territories. In this scenario, there is not a clear winner or loser. This scenario reflects the real-world dilemma that both countries must face when either one or both countries employ reconnaissance satellites.

Scenario # 3

Should Canada become involved in the development and deployment of reconnaissance satellites? What kind of strategies would she be able to pursue? This is an important question for Canada because Canada is one of the few countries that is in a position to develop and deploy reconnaissance satellites. It already possesses a highly advanced telecommunications satellite network and is a world leader in the field of remote sensing. The question to be studied in this scenario will be examined as a n-person non-constant sum game. This assumes that the strategies of the superpowers and their present dominance in this industry will change only marginally if Canada does become an active player in this field. Canada's reasons for becoming more active in this field may be both economic and strategic.

> ...We cannot dissolve NORAD as long as our defensive operations are ground based or even partially air based. Hence, our problems will revolve around (a) detection and (b) command functions, that is who should do what? and to what extent? Obviously for Canada at least, the ABMD/S (Anti-Ballistic Missile Defence System), does indicate a gradual shift of ABM toward the north and the possibility, of space-defence ground based forces cannot perform. Such a horizontal-vertical shift from south to north involves Canada more than in the past, in the defence of North America... from the standpoint of effectiveness, such a step is inevitable.[38]

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[38] Nicholas Nyiri, Alternatives to Nuclear Warfare: A Possible Role for Canada in the US/USSR Nuclear Balance, 2 volumes, Occassional Paper #2, (Waterloo: Waterloo Lutheran University) 1971, p. 453.

To speak to this point Canada shall be given a definition and other players will be included to define the position of Canada in the world.

The players in this game shall be defined thus:

n_1 = Canada

n_2 = US

n_3 = SU

n_4 = US/SU

n_5 = UN (not to include n_2, n_3, n_4)

n_6 = UN (includes n_2, n_3, n_4)

n_7 = Other players (future players)

Coalition structure and formulation play an important role in international affairs. Shubik states that for a set of seven players there are a maximum number of 127 coalitions. For n players there would be $2^n - 1$ coalitions that could be devised. Therefore, $2^7 - 1 = 127$ and $2^6 - 1 = 63$. These are the maximum number of coalitions for Canada in considering her military options when she decides to deploy reconnaissance satellites (assuming she decides to do so). If Canada does not develop and deploy reconnaissance satellites then the short term advantages according to this strategy would be mainly economic in nature. The result would be that, in the long term, Canada would experience a loss of competitiveness on the world market. This would be disadvantageous for Canada's future in the high technology market in this field. On the other hand, if Canada develops and deploys reconnaissance satellites then the long term advantages would be economic as Canada would become more competitive in the world market.

The payoffs for Canada in her decision to deploy satellites by herself or in coalition with others is not easy to define. It is possible to assign an arbitrary application of payoffs for each player based on their present political and military power today. A maximum payoff or value of the strategy (VS) would be 5 and would be assigned to n_6 and n_3. A minimum payoff would be 1 (n_5 and n_7).Canada would be assigned a value of 3 for she is much weaker than $n_{2,3,4,}$ and $_6$ but stronger than n_7. If Canada chooses to develop and deploy reconnaissance satellites then Canada must first weigh all the possible coalitions that are available to her. She has a maximum number of 127 coalitions (see page previous) but assuming that she discounts the Soviet Union (n_3) as being a coalition choice, then her coalition choices are only 63. In and by herself, Canada's non-coalition strength amounts to only 3. In any other combination however, her strength as a measure of S could be increased dramatically e.g. if $n_1 + n_3$ then S = 7. One must also note that von Neuman and Morganstern proved that the V of S may be challenged by the V of another coalition.

Therefore V(S) = V (O) where O = Other(assuming that the game is purely competitive as it is in this scenario).

Therefore, V(S) = V(O) and visa versa,

Thus if V(S) = V(O) then

Canada cannot be in a position to claim any advantage in shifting strategies or in forming new alliances in the near future.

This assumes that $Vn_1 + V(n_2+n_4+n_5+n_6) = V(n_1+n_2+n_4+n_5 \text{ u } n_6)$ where u represents a union of all five groups into one bloc as von Neuman and Morganstern suggest.

On balance, Canada is not in a position to develop and deploy reconnaissance satellites for the short term. However, this game consists of changing strategies and is of infinite, or at least, indeterminate length. Canada's strategy in this field should be to delay her decision to become an independent force in the development and deployment of reconnaissance satellties. At the same time, Canada should re-examine her traditional ties with the U.S. as Nyiri has suggested and should consider pursuing new strategies based on different coalitions other than those with the U.S.

(5) The Problems Associated With Space Debris

The future leaves many unanswered question for photoreconnaissance satellites as well as the other types. The majority of satellites other than photoreconnaissance are telecommunications satellites. They exist almost exclusively in the geostationary ring. The geostationary ring is the ring that is most in demand for it is useful not only to the superpowers but to smaller powers as well and, just as importantly, to the business world, namely telecommunications groups. As the increased need for telecommunications develops, there exists an increased probability that satellites on this ring may collide. Such an event would have disastrous consequences for the world. When satellites break up they do not fall out of orbit immediatly. In fact, they are more apt to stay in orbit and continue to circle the earth. In lower orbits this phenomenon is less of a problem because the satellite is slowly drawn into the ozonosphere and then eventually burns up or enters the atmosphere in fragments (this is why when COSMOS 1435 broke up, some parts of the satellite took more than a month to re-enter the atmosphere - they retained a crude earth orbit of the satellite which they were once a part of). The problem with satellites or satellite fragments in the geostationary ring is that they are not drawn towards the earth where the fragments will be destroyed. In the geostationary ring the apogee - perigee differential is almost nil and the fragments would simply circle the earth indefinitely until they were taken out of orbit. This would affect the communications satellites that were still functioning normally because these fragments would disrupt radio signals or, even worse, could collide with the satellites that were still functioning normally. Such a scenario is not unlikely if the geo-stationary ring becomes overcrowded with satellites.

This problem points to the need for scientists to build bigger multi-function telecommunications satellites which could handle the information that three satellites might do today. Scientists might soon develop such satellites in outer space for a number of reasons. Firstly, there has been a move for a number of technologically advanced powers (including Canada) to place their own satellites on the geostationary ring and not cooperate with other countries to share a satellite(this was discussed previously). Secondly, when satellites become dormant (as the ANIK I now is) they may remain in outer space, taking up valuable space that might otherwise be used by a functioning satellite. This problem may be solved in the future when American Space Shuttle flights become a regular event. But for the present, the problem remains. Thirdly, the two superpowers will want to retain their own satellite systems in geostationary orbit so as to limit the possibilities of the enemy decoding radio signals - especially those signals that transfer military or diplomatic information. It is unlikely that NATO and Warsaw Pact countries would ever have a joint telecommunications system. Fourthly, in the event of a nuclear war, it would be much easier for the enemy to strike at a single, multi-function satellite and paralyze it. This would deal a heavier blow to the other side than if there were a number of satellites in the orbit that could pick up the "flack" that was caused by the destruction of a couple of satellites. Again, the problem is a political - military one and in the context of current international relations the possibility that east and west may try to share satellite facilities in geostationary orbit seems to be remote at best. The problem of overcrowding on this ring may be present for a long time to come.

Engineers are having to devise new ways to cope with orbital crowding. They are focusing on technologies to increase communications capacity through the use of higher radio frequencies and more sophisticated satellites that make more efficient use of their place in orbit. It is estimated that by 1985, the number of satellites in outer space could rise to over 10,000.[39] This is a conservative estimate.

Military analysts, however, do not appear to be aware of this problem. Many of the strategies that are being planned for outer space have not recognized the fact that there may not be room to deploy the satellites that are being proposed in military games and strategies.

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[39] Leo Heaps, Operation Morning Light, (New York, Paddington press, 1978), p. 26.

Lt. General Daniel Graham (U.S. Army Retired) has proposed as a first line of defense against nuclear hardened missile silos on earth that hundreds of space-based satellite systems be deployed in various orbits in outer space. The satellites would carry miniature interceptor missiles which would meet the ground-based missiles only minutes after they left their silos.[40] General Graham's scenario might be to an extent workable but it is hardly practical. Even in lower orbits there is not enough room to place hundreds of satellites in outer space and to expect them to operate properly when placed into orbit is not realistic. The radio transmissions that are needed to control these satellites would be difficult to direct unless a safe distance between these satellites were enforced (i.e. 30km.).

In 1981, 67 military satellites were launched by the Superpowers.[41] Of this number, 58% were reconnaissance.[42] Increasingly satellites are returning information via radio wave. If outer space becomes too crowded, then the ability of these satellites to transfer the information that is obtained would be hampered. This would have important ramifications for all

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[40] Toronto Star, July 25, 1982, p.B6.

[41] Stockholm International Peace Research Institute, World Armaments Yearbook 1982 (Stockholm: Stockholm International Peace Research Institute, 1982), pp. 306-312.

[42] Stockholm International Peace Research Institute, Op Cit., pp. 306-312.

military satellites. Some seventy-five percent of all satellites are military satellites.[43]

In the United States, fifteen billion dollars, (about forty percent of the total space budget) has been spent on the military space program in the past decade. Although comparable figures are not easily available about the Soviet Union and its space budget, it is most probable that their spending on outer space is comparable to that of the Americans. If American and Soviet planners intend to use artificial satellites to a larger degree in the future, they will have to be prepared to invest more resources to "clean up" outer space so as to prevent the collision of future satellites as well as allowing the satellites that are now deployed and that will be deployed to function effectively.[44]

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[43] Stockholm International Peace Research Institute, World Armaments Yearbook 1981, (Stockholm: Stockholm International Peace Research Institute, 1981), p. 291.

[44] Stockholm International Peace Research Institute, World Armaments 1982, Op Cit., p. 121.

CONCLUSIONS

In spite of the enormous importance of reconnaissance satellites there has been a considerable lack of discussion as to their technical, legal, and military implications. This may be due in part to the fact that they did not even exist three decades ago. As chapter one has indicated, reconnaissance satellites have undergone tremendous technical changes. The earliest models such as the U.S. Discoverer satellite and the Russian Cosmos Four satellite could only take low resolution pictures. The satellites were operative only in the daytime and under cloud free conditions. The 1960's saw the militarization of space primarily through the developments that took place in reconnaissance satellites. The introduction of the Big Bird in the U.S. turned satellite reconnaissance into an art and gave satellites the prominent role that they would now play in the arms race. In Russia, satellite reconnaissance developed multi-purpose capabilities with the development and deployment of Cosmos 208 which lengthened the amount of time that satellites could stay in orbit.

The practical military uses of these instruments have been vitally important in the space race to this point. The use of reconnaissance satellites has already affected both war and military strategy. As early as 1961, reconnaissance satellites had ended fears of a massive Soviet ICBM buildup and verified for the Americans that the ICBM force in the Soviet Union did not constitute a major threat to America.[1] But the Americans and the Russians have used satellites for much more than arms control monitoring.

In the war in the Middle East in 1973, the number of Soviet launches doubled in outer space. That indicates the importance of receiving up to date information during a crisis period. The Americans have engaged spy satellites in the monitoring of border wars in areas such as Iran and Iraq and in the U.S.S.R. - Afghanistan conflict. This monitoring by satellite has also been practiced by the Soviets. The Falkland Islands conflict between Britain and Argentina unofficially involved the use of reconnaissance satellites to a large degree by the Russians. Cosmos 1372, an ocean surveillance satellite, not only covered the positioning of British and Argentinian troops on land, but followed the path of the British Fleet as it headed south through the Atlantic ocean. The Soviets were vocally, if not militarily, supporting the Argentinians in this conflict and the information that was obtained by the Russians could have been transferred to the Argentinians.[2]

The most sophisticated reconnaissance satellites of today have all but eliminated the need for on-ground surveillance of military sites. But

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[1]Lawrence Freeman, U.S. Intelligence and the Soviet Strategic Threat, (Boulder, Colo., Westview Press, 1977) p. 67.

[2]This has been suggested bv a number of groups.

reconnaissance satellites are still, in some ways, in the development stages. At present, researchers are trying to achieve better, more detailed pictures via satellite. They are trying to amalgamate the abilities of reconnaissance satellites that will employ other remote sensing techniques as well as telecommunications satellites that will be able to make the satellite a multifunctional instrument. The problem, however, as discussed in chapter three is that this type of satellite is more vulnerable to attack and it puts the enemy in a better position to inflict a greater blow on the other side. This development presents greater political challenges than it does technical ones (although these are also very important).

Another problem is that reconnaissance satellites are not an indisputable verifier of enemy activities. Inferences must still be drawn when an object, above or below the ground, is photographed. There is no standard way of defining what a photograph reveals. To one military analyst an object on the ground might be interpreted as being intended for use in a hostile manner, while another analyst might perceive the picture in a different manner. A recent example is the CIA report of a Cuban military base being constructed in Nicaragua for the purposes of deploying missile silos against the United States. The construction site eventually revealed that the area under investigation was not a missile silo base, but rather, a civilian airport. Whether or not an airport was actually planned is not of importance. What is important is that objects may be accurately identified in a photograph, but the purposes for which those objects will be used may in fact be different from those which analysts may either believe or may want to believe. It is in this way that many who fear that the arms race has grown out of control, think that reconnaissance satellites which keep records of the enemy that would otherwise be unattainable may do just as much to contribute to the arms race and the "nuclear confrontation" mentality as they may reduce the number of weapons on earth.

This was one of the underlying themes of chapter one. The chapter detailed what satellites were and how they have been used. It explored their history and their past strategic significance. The chapter detailed how remote sensing satellites have important military applications, even if, prima facie, their primary purposes may be civilian in application. The intent of the chapter was to leave the reader with the impression that satellites are a highly developed medium of reconnaissance and that, because they are so developed, and so important in a strategic axiom to the arms race in general, their future in the arms race will continue to be of importance in global military strategy. As just stated, this is true even of civilian satellites. All satellites, although intended primarily for civilian applications, can collect information that allows one side to obtain data about the enemy, its personnel, and its military equipment.

At present, reconnaissance satellites are able to identify new missile silos, detect shifts in operational procedures suggesting a change in military hardware, and can observe the construction of launching sites and radar installations. Reconnaissance satellites are a necessary instrument for war and a necessary precursor to peace. However, some practical problems must first be overcome before their place in the arms race is fully understood. The international legal community must define what outer space is, where it is, and how it should be governed. This essentially, was the theme of chapter two. The treaties that govern man's use of outer space are too general to deal effectively with the question of satellites in general and reconnaissance satellites in particular. There must be a clear definition as to what artificial satellites are and how their activities should be regulated.

New treaties will have to detail exactly what reconnaissance satellites can and cannot do. They will have to determine if the flight paths of satellites should remain unrestricted and what barriers, if any, should be imposed on satellties with the information that they are allowed to collect. Future military treaties, especially those between the superpowers; must detail whether or not interceptor/destructor, fractional orbital bombardment systems, radar, and nuclear-tipped weapons will be allowed to orbit in space, and if so, in what capacity. It is crucial to the arms race that the powers of all satellites be explicitly defined so as to set limits on both their capabilities and their numbers of weapons.

The intent of chapter three was to amalgamate the themes of the two preceding chapters and examine the overall military importance of reconnaissance satellites as well as the military options that were open to Canada as these satellites continued to grow in importance in the arms race. The chapter emphasised that Canada must consider its options in the field of remote sensing and reconnaissance. It is technically possible for Canada to develop and deploy its own remote sensors. Canada must decide if it can afford to orbit reconnaissance satellites in order to contribute independently to the defense of its own borders. In this regard, Canada must also be prepared to accommodate the changes in the satellite industry as a whole which will occur in this decade. This will mean spending many millions of dollars on research and development of both reconnaissance satellites and as parts for American projects.

Chapter three also examined how outer space will be used in the future for man's military exploits. As to the question of laser technology in outer space for instance, there remains some uncertainty as to how far the Soviets and Americans have gone and will be willing to go in developing such weapons. The next SALT agreement may contain references to such systems and may make provisions for some testing of these weapons in outer space. If there were a significant slowing of the arms race, the amount of research and development being done on the arming of artificial satellites would probably decrease. But the decrease would probably be in the area of laser and nuclear-tipped satellites that are now being developed. This would depend mainly on the attitudes towards a military buildup in both the Kremlin and the White House. If the Administration continues to place a priority on achieving military superiority over the Soviets, then one can expect to witness a substantial increase in outer space research.

If, on the other hand, a future Administration attempts to lessen the amount of money that the Defense Department has been able to receive from the present administration, then the outer space programs would almost certainly be the first to be cut. This would be the case because research into deploying such weapons is still in its infancy and to continue such research would be a signal to the Soviets to do the same. For its part, the Soviet Union has shown a willingness to keep outer space weapons free, not because it is interested in such an ideal but because it is aware that the United States is technically superior in the exploration and exploitation of outer space.

Regardless of whether or not the superpowers intend to militarize space in the future, it seems certain that the area of remote sensing would not be affected, partly because remote sensing has peaceful as well as military applications, but more importantly because remote sensors - whether civilian or military - already play a pivitol role in the arms race. Remote sensors detail the weapons and weapon systems of the enemy and provide crucial strategic data on where those weapon systems are deployed.

But the moral questions remain. Is it ethical to have reconnaissance satellites in outer space and to what extent should their capabilities be controlled? The majority of developments in remote sensor technology have spurred a number of benefits for many other sectors of man's civilization. Farming and fishing has been made more cost efficient. Ecological and environmental problems are now easier to identify and to solve. Even the most inhospitable areas of the earth have now been accurately mapped. If anything, the future for remote sensing satellites should be accorded high priority because their ability to affect civilization is substantial. But no one should expect that the benefits of remote sensing satellites will be pursued while the strategic advantages will be ignored. It is not possible to pursue one ideal and not the other. Ultimately, the future for reconnaissance satellites will be related to the arms race in general. But beyond the arms race these satellites open a Pandora's Box of options for military powers. Their strength lies in their ability to keep a close eye on the enemy. That, unfortunately, is also their weakness. Reconnaissance satellites will survive in the coming years. Nuclear missiles may not.

For the present, the two-person zero sum option seems to be the most preferred in assessing the role of reconnaissance satellites in the arms race - a choice that is not unusual in the study of either international relations or military science.

APPENDICES

APPENDIX I

INTERNATIONAL CIVIL AVIATION CONFERENCE

CONVENTION ON INTERNATIONAL CIVIL AVIATION

PREAMBLE

WHEREAS the future development of international civil aviation can greatly help to create and preserve friendship and understanding among the nations and peoples of the world, yet its abuse can become a threat to the general security, and

WHEREAS it is desirable to avoid friction and to promote that co-operation between nations and peoples upon which the peace of the world depends,

THEREFORE, the undersigned governments having agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically,

Have accordingly concluded this Convention to that end.

PART I—AIR NAVIGATION

CHAPTER I

GENERAL PRINCIPLES AND APPLICATION OF THE CONVENTION

Article 1

Sovereignty.

The contracting States recognize that every State has complete and exclusive sovereignty over the airspace above its territory.

Article 2

Territory.

For the purposes of this Convention the territory of a State shall be deemed to be the land areas and territorial waters adjacent thereto under the sovereignty, suzerainty, protection or mandate of such State.

Article 3

Civil and State aircraft.

(*a*) This Convention shall be applicable only to civil aircraft, and shall not be applicable to State aircraft.

(*b*) Aircraft used in military, customs and police services shall be deemed to be State aircraft.

(*c*) No State aircraft of a contracting State shall fly over the territory of another State or land thereon without authorization by special agreement or otherwise, and in accordance with the terms thereof.

(*d*) The contracting States undertake, when issuing regulations for their State aircraft, that they will have due regard for the safety of navigation of civil aircraft.

Article 4

Misuse of civil aviation.

Each contracting State agrees not to use civil aviation for any purpose inconsistent with the aims of this Convention.

CHAPTER II

Flight over Territory of Contracting States

Article 5

Right of non-scheduled flight.

Each contracting State agrees that all aircraft of the other contracting States, being aircraft not engaged in scheduled international air services shall have the right, subject to the observance of the terms of this Convention, to make flights into or in transit non-stop across its territory and to make stops for non-traffic purposes without the necessity of obtaining prior permission, and subject to the right of the State flown over to require landing. Each contracting State nevertheless reserves the right, for reasons of safety of flight, to require aircraft desiring to proceed over regions which are inaccessible or without adequate air navigation facilities to follow prescribed routes, or to obtain special permission for such flights.

Such aircraft, if engaged in the carriage of passengers, cargo, or mail for remuneration or hire on other than scheduled international air services, shall also, subject to the provisions of Article 7, have the privilege of taking on or discharging passengers, cargo, or mail, subject to the right of any State where such embarkation or discharge takes place to impose such regulations, conditions or limitations as it may consider desirable.

Article 6

Scheduled air services.

No scheduled international air service may be operated over or into the territory of a contracting State, except with the special permission or other authorization of that State, and in accordance with the terms of such permission or authorization.

Article 7

Cabotage.

Each contracting State shall have the right to refuse permission to the aircraft of other contracting States to take on in its territory passengers, mail and cargo carried for remuneration or hire and destined for another point within its territory. Each contracting State undertakes not to enter into any arrangements which specifically grant any such privilege on an exclusive basis to any other State or an airline of any other State, and not to obtain any such exclusive privilege from any other State.

Article 8

Pilotless aircraft.

No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of such authorization. Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft.

Article 9

Prohibited areas.

(*a*) Each contracting State may, for reasons of military necessity or public safety, restrict or prohibit uniformly the aircraft of other States from flying over certain areas of its territory, provided that no distinction in this respect is made between the aircraft of the State whose territory is involved, engaged in international scheduled airline services, and the aircraft of the other contracting States likewise engaged. Such prohibited areas shall be of reasonable extent and location so as not to interfere unnecessarily with air navigation. Descriptions of such prohibited areas in the territory of a contracting State, as well as any subsequent alterations therein, shall be communicated as soon as possible to the other contracting States and to the International Civil Aviation Organization.

(*b*) Each contracting State reserves also the right, in exceptional circumstances or during a period of emergency, or in the interest of public safety, and with immediate effect, temporarily to restrict or prohibit flying over the whole or any part of its territory, on condition that such restriction or prohibition shall be applicable without distinction of nationality to aircraft of all other States.

(*c*) Each contracting State, under such regulations as it may prescribe, may require any aircraft entering the areas contemplated in sub-paragraphs (*a*) or (*b*) above to effect a landing as soon as practicable thereafter at some designated airport within its territory.

Article 10

Landing at customs airport.

Except in a case where, under the terms of this Convention or a special authorization, aircraft are permitted to cross the territory of a contracting State without landing, every aircraft which enters the territory of a contracting State shall, if the regulations of that State so require, land at an airport designated by that State for the purpose of customs and other examination. On departure from the territory of a contracting State, such aircraft shall depart from a similarly designated customs airport. Particulars of all designated customs airports shall be published by the State and transmitted to the International Civil Aviation Organization established under Part II of this Convention for communication to all other contracting States.

Article 11

Applicability of air regulations.

Subject to the provisions of this Convention, the laws and regulations of a contracting State relating to the admission to or departure from its territory of aircraft engaged in international air navigation, or to the operation and navigation of such aircraft while within its territory, shall be applied to the aircraft of all contracting States without distinction as to nationality, and shall be complied with by such aircraft upon entering or departing from or while within the territory of that State.

Article 12

Rules of the air.

Each contracting State undertakes to adopt measures to insure that every aircraft flying over or manœuvring within its territory and that every aircraft carrying its nationality mark, wherever such aircraft may be, shall comply with the rules and regulations relating to the flight and manœuvre of aircraft there in force. Each contracting State undertakes to keep its own regulations in these respects uniform, to the greatest possible extent, with those established from time to time under this Convention. Over the high seas, the rules in force shall be those established under this Convention. Each contracting State undertakes to insure the prosecution of all persons violating the regulations applicable.

APPENDIX II

110 (II). MEASURES TO BE TAKEN AGAINST PROPAGANDA AND THE INCITERS OF A NEW WAR

Whereas in the Charter of the United Nations the peoples express their determination to save succeeding generations from the scourge of war, which twice in our lifetime has brought untold sorrow to mankind, and to practice tolerance and live together in peace with one another as good neighbours, and

Whereas the Charter also calls for the promotion of universal respect for, and observance of, fundamental freedoms which include freedom of expression, all Members having pledged themselves in Article 56 to take joint and separate action for such observance of fundamental freedoms,

The General Assembly

1. *Condemns* all forms of propaganda, in whatsoever country conducted, which is either designed or likely to provoke or encourage any threat to the peace, breach of the peace, or act of aggression;

2. *Requests* the Government of each Member to take appropriate steps within its constitutional limits:

a. To promote, by all means of publicity and propaganda available to them, friendly relations among nations based upon the Purposes and Principles of the Charter;

b. To encourage the dissemination of all information designed to give expression to the undoubted desire of all peoples for peace;

3. *Directs* that this resolution be communicated to the forthcoming Conference on Freedom of Information.

Hundred and eigth plenary meeting,
3 November 1947.

NOTING that the terms of office of the members of the Committee on the Peaceful Uses of Outer Space expire at the end of 1961,

NOTING the report of the Committee on the Peaceful Uses of Outer Space.[1]

1. ***DECIDES*** to continue the membership of the Committee on the Peaceful Uses of Outer Space as set forth in General Assembly resolution 1472 (XIV) and to add Chad, Mongolia, Morocco and Sierra Leone to its membership in recognition of the increased membership of the United Nations since the Committee was established;

2. ***REQUESTS*** the Committee to meet not later than 31 March 1962 to carry out its mandate as contained in General Assembly resolution 1472 (XIV), to review the activities provided for in the present resolution and to make such reports as it may consider appropriate.

1. A/4987

APPENDIX III

UNITED NATIONS
RESOLUTIONS ADOPTED BY THE GENERAL ASSEMBLY

ON THE REPORT OF THE FIRST COMMITTEE (A/5026), 1721 (XVI), 20 DECEMBER 1961. *INTERNATIONAL CO-OPERATION IN THE PEACEFUL USES OF OUTER SPACE*

A

THE GENERAL ASSEMBLY,

RECOGNIZING the common interest of mankind in furthering the peaceful uses of outer space and the urgent need to strengthen international co-operation in this important field,

BELIEVING that the exploration and use of outer space should be only for the betterment of mankind and to the benefit of States irrespective of the stage of their economic or scientific development,

1. *COMMENDS* to States for their guidance in the exploration and use of outer space the following principles:

a. *International law, including the Charter of the United Nations, applies to outer space and celestial bodies:*

b. *Outer space and celestial bodies are free for exploration and use by all States in conformity with international law and are not subject to national appropriation:*

2. *INVITES* the Committee on the Peaceful Uses of Outer Space to study and report on the legal problems which may arise from the exploration and use of outer space

APPENDIX IV

1962 (XVIII). DECLARATION OF LEGAL PRINCIPLES GOVERNING THE ACTIVITIES OF STATES IN THE EXPLORATION AND USE OF OUTER SPACE

The General Assembly,

Inspired by the great prospects opening up before mankind as a result of man's entry into outer space,

Recognizing the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes,

Believing that the exploration and use of outer space should be carried on for the betterment of mankind and for the benefit of States irrespective of their degree of economic or scientific development,

Desiring to contribute to broad international co-operation in the scientific as well as in the legal aspects of exploration and use of outer space for peaceful purposes,

Believing that such co-operation will contribute to the development of mutual understanding and to the strengthening of friendly relations between nations and peoples,

Recalling its resolution 110 (II) of 3 November 1947, which condemned propaganda designed or likely to provoke or encourage any threat to the peace, breach of the peace, or act of aggression, and considering that the aforementioned resolution is applicable to outer space,

Taking into consideration its resolutions 1721 (XVI) of 20 December 1961 and 1802 (XVII) of 14 December 1962, adopted unanimously by the States Members of the United Nations,

Solemnly declares that in the exploration and use of outer space States should be guided by the following principles:

1. The exploration and use of outer space shall be carried on for the benefit and in the interest of all mankind.

2. Outer space and celestial bodies are free for exploration and use by all States on a basis of equality and in accordance with international law.

3. Outer space and celestial bodies are not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.

4. The activities of States in the exploration and use of outer space shall be carried on in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding.

[1] *Ibid., Eighteenth Session, Annexes,* agenda item 74, document A/5415/Rev.1.

5. States bear international responsibility for national activities in outer space, whether carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried on in conformity with the principles set forth in the present Declaration. The activities of non-governmental entities in outer space shall require authorization and continuing supervision by the State concerned. When activities are carried on in outer space by an international organization, responsibility for compliance with the principles set forth in this Declaration shall be borne by the international organization and by the States participating in it.

6. In the exploration and use of outer space, States shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space with due regard for the corresponding interests of other States. If a State has reason to believe that an outer space activity or experiment planned by it or its nationals would cause potentially harmful interference with activities of other States in the peaceful exploration and use of outer space, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State which has reason to believe that an outer space activity or experiment planned by another State would cause potentially harmful interference with activities in the peaceful exploration and use of outer space may request consultation concerning the activity or experiment.

7. The State on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and any personnel thereon, while in outer space. Ownership of objects launched into outer space, and of their component parts, is not affected by their passage through outer space or by their return to the earth. Such objects or component parts found beyond the limits of the State of registry shall be returned to that State, which shall furnish identifying data upon request prior to return.

8. Each State which launches or procures the launching of an object into outer space, and each State from whose territory or facility an object is launched, is internationally liable for damage to a foreign State or to its natural or juridical persons by such object or its component parts on the earth, in air space, or in outer space.

9. States shall regard astronauts as envoys of mankind in outer space, and shall render to them all possible assistance in the event of accident, distress, or emergency landing on the territory of a foreign State or on the high seas. Astronauts who make such a landing shall be safely and promptly returned to the State of registry of their space vehicle.

1280th plenary meeting,
13 December 1963.

APPENDIX V

UNITED NATIONS
RESOLUTION ADOPTED BY THE GENERAL ASSEMBLY

ON THE REPORT OF THE FIRST COMMITTEE (A 5571) 1884 (XVIII), 17 OCTOBER 1963, *QUESTION OF GENERAL AND COMPLETE DISARMAMENT*

THE GENERAL ASSEMBLY,

RECALLING its resolution 1721 A (XVI) of 20 December 1961, in which it expressed the belief that the exploration and use of outer space should be only for the betterment of mankind,

DETERMINED to take steps to prevent the spread of the arms race to outer space,

1. *WELCOMES* the expressions by the Union of Soviet Socialist Republics and the United States of America of their intention not to station in outer space any objects carrying nuclear weapons or other kinds of weapons of mass destruction;

2. *SOLEMNLY CALLS UPON* all States:

a. To refrain from placing in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, installing such weapons on celestial bodies, or stationing such weapons in outer space in any other manner;

b. To refrain from causing, encouraging or in any way participating in the conduct of the foregoing activities.

plosions, including all such explosions underground, the conclusion of which, as the Parties have stated in the Preamble to this Treaty, they seek to achieve.

2. Each of the Parties to this Treaty undertakes furthermore to refrain from causing, encouraging, or in any way participating in, the carrying out of any nuclear weapon test explosion, or any other nuclear explosion, anywhere which would take place in any of the environments described, or have the effect referred to, in paragraph 1 of this Article.

ARTICLE II

1. Any Party may propose amendments to this Treaty. The text of any proposed amendment shall be submitted to the Depositary Governments which shall circulate it to all Parties to this Treaty. Thereafter, if requested to do so by one-third or more of the Parties, the Depositary Governments shall convene a conference, to which they shall invite all the Parties, to consider such amendment.

2. Any amendment to this Treaty must be approved by a majority of the votes of all the Parties to this Treaty, including the votes of all of the Original Parties. The amendment shall enter into force for all Parties upon the deposit of instruments of ratification by a majority of all the Parties, including the instruments of ratification of all of the Original Parties.

ARTICLE III

1. This Treaty shall be open to all States for signature. Any State which does not sign this Treaty before its entry into force in accordance with paragraph 3 of this Article may accede to it at any time.

2. This Treaty shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the Original Parties – the United States of America, the United Kingdom of Great Britain and Northern Ireland, and the Union of Soviet Socialist Republics – which are hereby designated the Depositary Governments.

3. This Treaty shall enter into force after its ratification by all the Original Parties and the deposit of their instruments of ratification.

4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Treaty, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification of and accession to this Treaty, the date of its entry into force, and the date of receipt of any requests for conferences or other notices.

6. This Treaty shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

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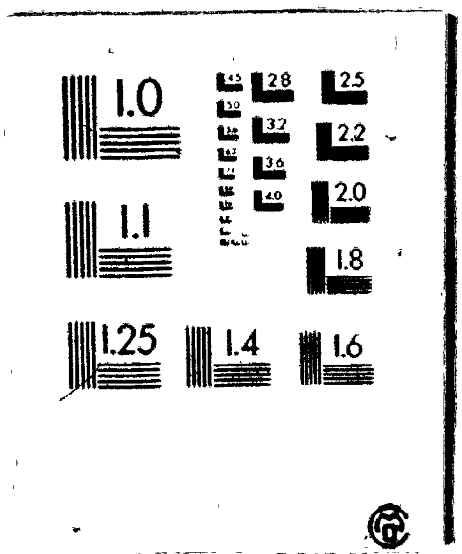

ARTICLE IV

This Treaty shall be of unlimited duration.

Each Party shall in exercising its national sovereignty have the right to withdraw from the Treaty if it decides that extraordinary events, related to the subject matter of this Treaty, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other Parties to the Treaty three months in advance.

ARTICLE V

This Treaty, of which the English and Russian texts are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Treaty shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding States.

IN WITNESS WHEREOF the undersigned, duly authorized, have signed this Treaty.

DONE in triplicate at the city of Moscow the fifth day of August, one thousand nine hundred and sixty-three.

For the Government of the United States of America.	For the Government of the United Kingdom of Great Britain and Northern Ireland:	For the Government of the Union of Soviet Socialist Republics:
Dean RUSK	HOME	A. GROMYKO

APPENDIX VI

TREATY GOVERNING THE EXPLORATION AND USE OF OUTER SPACE, INCLUDING THE MOON AND OTHER CELESTIAL BODIES

2222 (XXI)

The General Assembly,

Having considered the report of the Committee on the Peaceful Uses of Outer Space covering its work during 1966, and in particular the work accomplished by the Legal Sub-Committee during its fifth session, held at Geneva from 12 July through 4 August and at New York from 12 September through 16 September,

Noting further the progress achieved through subsequent consultations among States Members of the United Nations,

Reaffirming the importance of international co-operation in the field of activities in the peaceful exploration and use of outer space, including the moon and other celestial bodies, and the importance of developing the rule of law in this new area of human endeavour,

1. *Commends* the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, the text of which is annexed to this resolution;

2. *Requests* the depositary Governments to open the Treaty for signature and ratification at the earliest possible date;

3. *Expresses its hope* for the widest possible adherence to this Treaty;

4. *Requests* the Committee on the Peaceful Uses of Outer Space:

a. To continue its work on the elaboration of an agreement on liability for damages caused by the launching of objects into outer space and an agreement on assistance to and return of astronauts and space vehicles, which are on the agenda of the Committee;

b. To begin at the same time the study of questions relative to the definition of outer space and the utilization of outer space and celestial bodies, including the various implications of space communications;

c. To report to the twenty-second session of the General Assembly on the progress of its work.

(1499th plenary meeting,
19 December 1966)

APPENDIX VII

TREATY[1] BANNING NUCLEAR WEAPON TESTS IN THE ATMOSPHERE, IN OUTER SPACE AND UNDER WATER. SIGNED AT MOSCOW, ON 5 AUGUST 1963

The Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland, and the Union of Soviet Socialist Republics, hereinafter referred to as the "Original Parties",

Proclaiming as their principal aim the speediest possible achievement of an agreement on general and complete disarmament under strict international control in accordance with the objectives of the United Nations which would put an end to the armaments race and eliminate the incentive to the production and testing of all kinds of weapons, including nuclear weapons,

Seeking to achieve the discontinuance of all test explosions of nuclear weapons for all time, determined to continue negotiations to this end, and desiring to put an end to the contamination of man's environment by radioactive substances,

Have agreed as follows:

ARTICLE I

1. Each of the Parties to this Treaty undertakes to prohibit, to prevent, and not to carry out any nuclear weapon test explosion, or any other nuclear explosion, at any place under its jurisdiction or control:

a. in the atmosphere; beyond its limits, including outer space; or under water, including territorial waters or high seas; or

b. in any other environment if such explosion causes radioactive debris to be present outside the territorial limits of the State under whose jurisdiction or control such explosion is conducted. It is understood in this connection that the provisions of this subparagraph are without prejudice to the conclusion of a treaty resulting in the permanent banning of all nuclear test ex-

[1] The Treaty came into force on 10 October 1963, the date of deposit of the instruments of ratification by the Governments of the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland and the United States of America with each of the three depositary Governments, in accordance with paragraph 3 of article III.

Ratifications and accession (a)

Instruments were deposited with the Government of the United States of America by the Governments of the following States on the dates indicated:

New Zealand	10 October 1963
South Africa	10 October 1963 (a)
Poland	14 October 1963

Certified statement was registered by the United States of America on 22 October 1963.

APPENDIX VIII

TREATY ON PRINCIPLES GOVERNING THE ACTIVITIES OF STATES IN THE EXPLORATION AND USE OF OUTER SPACE, INCLUDING THE MOON AND OTHER CELESTIAL BODIES

The States Parties to this Treaty,

Inspired by the great prospects opening up before mankind as a result of man's entry into outer space,

Recognizing the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes,

Believing that the exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development,

Desiring to contribute to broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes,

Believing that such co-operation will contribute to the development of mutual understanding and to the strengthening of friendly relations between States and peoples,

Recalling resolution 1962 (XVIII) entitled "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space", which was adopted unanimously by the United Nations General Assembly on 13 December 1963,

Recalling resolution 1884 (XVIII), calling upon States to refrain from placing in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction or from installing such weapons on celestial bodies, which was adopted unanimously by the United Nations General Assembly on 17 October 1963,

Taking account of United Nations General Assembly resolution 110 (II) of 3 November 1947, which condemned propaganda designed or likely to provoke or encourage any threat to the peace, breach of the peace or act of aggression, and considering that the afore-mentioned resolution is applicable to outer space,

Convinced that a Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, will further the purposes and principles of the Charter of the United Nations,

Have agreed on the following:

ARTICLE I

The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.

ARTICLE II

Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.

ARTICLE III

States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding.

ARTICLE IV

States Parties to the Treaty undertake not to place in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.

The moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military manoeuvres on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited.

ARTICLE V

States Parties to the Treaty shall regard astronauts as envoys of mankind in outer space and shall render to them all possible assistance in the event of accident, distress, or emergency landing on the territory of another State Party or on the high seas. When astronauts make such a landing, they shall be safely and promptly returned to the State of registry of their space vehicle

In carrying on activities in outer space and on celestial bodies, the astronauts of one State Party shall render all possible assistance to the astronauts of other States Parties.

States Parties to the Treaty shall immediately inform the other States

Parties to the Treaty or the Secretary-General of the United Nations of any phenomena they discover in outer space, including the moon and other celestial bodies, which could constitute a danger to the life or health of astronauts.

ARTICLE VI

States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the State concerned. When activities are carried on in outer space, including the moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.

ARTICLE VII

Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies.

ARTICLE VIII

A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts, is not affected by their presence in outer space or on a celestial body or by their return to the Earth. Such objects or component parts found beyond the limits of the State Party to the Treaty on whose registry they are carried shall be returned to that State Party, which shall, upon request, furnish identifying data prior to their return.

ARTICLE IX

In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, may request consultation concerning the activity or experiment.

ARTICLE X

In order to promote international cooperation in the exploration and use of outer space, including the Moon and other celestial bodies, in conformity with the purposes of this Treaty, the States Parties to the Treaty shall consider on a basis of equality any requests by other States Parties to the Treaty to be afforded an opportunity to observe the flight of space objects launched by those States.

The nature of such an opportunity for observation and the conditions under which it could be afforded shall be determined by agreement between the States concerned.

ARTICLE XI

In order to promote international cooperation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the Moon and other celestial bodies, agree to inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities. On receiving the said information, the Secretary-General of the United Nations should be prepared to disseminate it immediately and effectively.

ARTICLE XII

All stations, installations, equipment and space vehicles on the Moon and other celestial bodies shall be open to representatives of other States Parties to the Treaty on a basis of reciprocity. Such representatives shall give reasonable advance notice of a projected visit, in order that appropriate consultations may be held and that maximum precautions may be taken to assure safety and to avoid interference with normal operations in the facility to be visited.

ARTICLE XIII

The provisions of this Treaty shall apply to the activities of States Parties to the Treaty in the exploration and use of outer space, including the Moon and other celestial bodies, whether such activities are carried on by a single State Party to the Treaty or jointly with other States, including cases where they are carried on within the framework of international intergovernmental organizations.

Any practical questions arising in connexion with activities carried on by international intergovernmental organizations in the exploration and use of outer space, including the Moon and other celestial bodies, shall be resolved by the States Parties to the Treaty either with the appropriate international organization or with one or more States members of that international organization, which are Parties to this Treaty.

ARTICLE XIV

1. This Treaty shall be open to all States for signature. Any State which does not sign this Treaty before its entry into force in accordance with paragraph 3 of this article may accede to it at any time.

2. This Treaty shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland and the United States of America, which are hereby designated the Depositary Governments.

3. This Treaty shall enter into force upon the deposit of instruments of ratification by five Governments including the Governments designated as Depositary Governments under this Treaty.

4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Treaty, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification of and accession to this Treaty, the date of its entry into force and other notices.

6. This Treaty shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

ARTICLE XV

Any State Party to the Treaty may propose amendments to this Treaty. Amendments shall enter into force for each State Party to the Treaty accepting the amendments upon their acceptance by a majority of the States

Parties to the Treaty and thereafter for remaining State Party to the Treaty on the date of acceptance by it.

ARTICLE XVI

Any State Party to the Treaty may give notice of its withdrawal from the Treaty one year after its entry into force by written notification to the Depositary Governments. Such withdrawal shall take effect one year from the date of receipt of this notification.

ARTICLE XVII

This Treaty, of which the Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Treaty shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding States.

IN WITNESS WHEREOF the undersigned, duly authorized, have signed this Treaty.

DONE in ...., at the cities of London, Moscow and Washington, the .... day of .... one thousand nine hundred and ....

Treaty — **Agreed Statements and Common Understandings**

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limitation provided for in paragraph 1 of Article V when it is brought out of the shop, plant, or other facility where it has been converted into a bomber of a type equipped for cruise missiles capable of a range in excess of 600 kilometers.

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6. The arms subject to the limitations provided for in this Treaty shall continue to be subject to these limitations until they are dismantled, are destroyed, or otherwise cease to be subject to these limitations under procedures to be agreed upon.

Agreed Statement. The procedures for removal of strategic offensive arms from the aggregate numbers provided for in the Treaty, which are referred to in paragraph 6 of Article VI of the Treaty, and which are to be agreed upon in the Standing Consultative Commission, shall include:

(a) procedures for removal from the aggregate numbers, provided for in Article V of the Treaty, of ICBM and SLBM launchers which are being converted from launchers of a type subject to the limitation provided for in Article V of the Treaty, into launchers of a type not subject to that limitation;

(b) procedures for removal from the aggregate numbers, provided for in Articles III and V of the Treaty, of bombers which are being converted from bombers of a type subject to the limitations provided for in Article III of the Treaty or in Articles III and V of the Treaty into airplanes or bombers of a type not so subject.

Common Understanding. The procedures referred to in subparagraph (b) of the Agreed Statement to paragraph 6 of Article VI of the Treaty for removal of bombers from the aggregate numbers provided for in Articles III and V of the Treaty shall be based upon the existence of functionally related observable differences which indicate whether or not they can perform the mission of a heavy bomber, or whether or not they can perform the mission of a bomber equipped for cruise missiles capable of a range in excess of 600 kilometers.

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7. In accordance with the provisions of Article XVII, the Parties will agree in the Standing Consultative Commission upon procedures to implement the provisions of this Article.

Article VII

1. The limitations provided for in Article III shall not apply to ICBM and SLBM test and training launchers or to space vehicle launchers for exploration and use of outer space. ICBM and SLBM test and training launchers are ICBM and SLBM launchers used only for testing or training.

Common Understanding. The term "testing," as used in Article VII of the Treaty, includes research and development.

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2. The Parties agree that:

(a) there shall be no significant increase in the number of ICBM or SLBM test and training launchers or in the number of such launchers of heavy ICBMs;

(b) construction or conversion of ICBM launchers at test ranges shall be undertaken only for purposes of testing and training;

First Agreed Statement. The term "significant increase," as used in subparagraph 2(a) of Article VII of the Treaty, means an increase of fifteen percent or more. Any new ICBM test and training launchers which replace ICBM test and training launchers at test ranges will be located only at test ranges.

Second Agreed Statement. Current test ranges where ICBMs are tested are located: for the United States of America, near Santa Maria, California, and at Cape Canaveral, Florida; and for the Union of Soviet Socialist Republics, in the areas of Tyura-Tam and Plesetskaya. In the future, each Party shall provide notification in the Standing Consultative Commission of the location of any other test range used by that Party to test ICBMs.

First Common Understanding. At test ranges where ICBMs are tested, other arms, including those not limited by the Treaty, may also be tested.

(c) there shall be no conversion of ICBM test and training launchers or of space vehicle launchers into ICBM launchers subject to the limitations provided for in Article III.

Second Common Understanding. Of the eighteen launchers of fractional orbital missiles at the test range where ICBMs are tested in the area of Tyura-Tam, twelve launchers shall be dismantled or destroyed and six launchers may be converted to launchers for testing missiles undergoing modernization.

Dismantling or destruction of the twelve launchers shall begin upon entry into force of the Treaty and shall be completed within eight months, under procedures for dismantling or destruction of these launchers to be agreed upon in the Standing Consultative Commission. These twelve launchers shall not be replaced.

Conversion of the six launchers may be carried out after entry into force of the Treaty. After entry into force of the Treaty, fractional orbital missiles shall be removed and shall be destroyed pursuant to the provisions of subparagraph 1(c) of Article IX and of Article XI of the Treaty and shall not be replaced by other missiles, except in the case of conversion of these six launchers for testing missiles undergoing modernization. After removal of the fractional orbital missiles, and prior to such conversion, any activities associated with these launchers shall be limited to normal maintenance requirements for launchers in which missiles are not deployed. These six launchers shall be subject to the provisions of Article VII of the Treaty and, if converted, to the provisions of the Fifth Common Understanding to paragraph 5 of Article II of the Treaty.

Article VIII

1. Each Party undertakes not to flight-test cruise missiles capable of a range in excess of 600 kilometers or ASBMs from aircraft other than bombers or to convert such aircraft into aircraft equipped for such missiles.

Agreed Statement. For purposes of testing only, each Party has the right, through initial construction or, as an exception to the provisions of paragraph 1 of Article VIII of the Treaty, by conversion, to equip for cruise missiles capable of a range in excess of 600 kilometers or for ASBMs no more than sixteen airplanes, including airplanes which are prototypes of bombers equipped for such missiles. Each Party also has the right, as an exception to the provisions of paragraph 1 of Article VIII of the Treaty, to flight-test from such airplanes cruise missiles capable of a range in excess of 600 kilometers and, after the date on which the Protocol ceases to be in force, to flight-test ASBMs from such airplanes as well, unless the Parties agree that they will not flight-test ASBMs after that date. The limitations provided for in Article III of the Treaty shall not apply to such airplanes.

The aforementioned airplanes may include only:

(a) airplanes other than bombers which, as an exception to the provisions of paragraph 1 of Article VIII of the Treaty, have been converted into airplanes equipped for cruise missiles capable of a range in excess of 600 kilometers or for ASBMs,

(b) airplanes considered to be heavy bombers pursuant to subparagraph 3(c) or 3(d) of Article II of the Treaty, and

(c) airplanes other than heavy bombers which, prior to March 7, 1979, were used for testing cruise missiles capable of a range in excess of 600 kilometers.

The airplanes referred to in subparagraphs (a) and (b) of this Agreed Statement shall be distinguishable on the basis of functionally related observable differences from airplanes which otherwise would be of the same type but cannot perform the mission of a bomber equipped for cruise missiles capable of a range in excess of 600 kilometers or for ASBMs.

The airplanes referred to in subparagraph (c) of this Agreed Statement shall not be used for testing cruise missiles capable of a range in excess of 600 kilometers after the expiration of a six-month period from the date of entry into force of the Treaty, unless by the expiration of that period they are distinguishable on the basis of functionally related observable differences from airplanes which otherwise would be of the same type but cannot perform the mission of a bomber equipped for cruise missiles capable of a range in excess of 600 kilometers.

First Common Understanding. The term "testing," as used in the Agreed Statement to paragraph 1 of Article VIII of the Treaty, includes research and development.

Second Common Understanding. The Parties shall notify each other in the Standing Consultative Commission of the number of airplanes, according to type, used for testing pursuant to the Agreed Statement to paragraph 1 of Article VIII of the Treaty. Such notification shall be provided at the first regular session of the Standing Consultative Commission held after an airplane has been used for such testing.

Third Common Understanding. None of the sixteen airplanes referred to in the Agreed Statement to paragraph 1 of Article VIII of the Treaty may be replaced, except in the event of the involuntary destruction of any such airplane or in the case of the dismantling or destruction of any such airplane. The procedures for such replacement and for removal of any such airplane from that number, in case of its conversion, shall be agreed upon in the Standing Consultative Commission.

2. Each Party undertakes not to convert aircraft other than bombers into aircraft which can carry out the mission of a heavy bomber as referred to in subparagraph 3(b) of Article II.

Article IX

1. Each Party undertakes not to develop, test, or deploy:

(a) ballistic missiles capable of a range in excess of 600 kilometers for installation on waterborne vehicles other than submarines, or launchers of such missiles;

Common Understanding to subparagraph (a). The obligations provided for in subparagraph 1(a) of Article IX of the Treaty do not affect current practices for transporting ballistic missiles.

(b) fixed ballistic or cruise missile launchers for emplacement on the ocean floor, on the seabed, or on the beds of internal waters and inland waters, or in the subsoil thereof, or mobile launchers of such missiles, which move only in contact with the ocean floor, the seabed, or the beds of internal waters and inland waters, or missiles for such launchers;

Agreed Statement to subparagraph (b). The obligations provided for in subparagraph 1(b) of Article IX of the Treaty shall apply to all areas of the ocean floor and the seabed, including the seabed zone referred to in Articles I and II of the 1971 Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and the Ocean Floor and in the Subsoil Thereof.

(c) systems for placing into Earth orbit nuclear weapons or any other kind of weapons of mass destruction, including fractional orbital missiles;

Common Understanding to subparagraph (c). The provisions of subparagraph 1(c) of Article IX of the Treaty do not require the dismantling or destruction of any existing launchers of either Party.

(d) mobile launchers of heavy ICBMs;

(e) SLBMs which have a launch-weight greater or a throw-weight greater than that of the heaviest, in terms of either launch-weight or throw-weight, respectively, of the light ICBMs deployed by either Party as of the date of signature of this Treaty, or launchers of such SLBMs; or

(f) ASBMs which have a launch-weight greater or a throw-weight greater than that of the heaviest, in terms of either launch-weight or throw-weight, respectively, of the light ICBMs deployed by either Party as of the date of signature of this Treaty.

First Agreed Statement to subparagraphs (e) and (f). The launch-weight of an SLBM or of an ASBM is the weight of the fully loaded missile itself at the time of launch.

Second Agreed Statement to subparagraphs (e) and (f). The throw-weight of an SLBM or of an ASBM is the sum of the weight of:

(a) its reentry vehicle or reentry vehicles;

(b) any self-contained dispensing mechanisms or other appropriate devices for targeting one reentry vehicle, or for releasing or for dispensing and targeting two or more reentry vehicles; and

(c) its penetration aids, including devices for their release.

Common Understanding to subparagraphs (e) and (f). The term "other appropriate devices," as used in the definition of the throw-weight of an SLBM or of an ASBM in the Second Agreed Statement to subparagraphs 1(e) and 1(f) of Article IX of the Treaty, means any devices for dispensing and targeting two or more reentry vehicles; and any devices for releasing two or more reentry vehicles or for targeting one reentry vehicle, which cannot provide their reentry vehicles or reentry vehicle with additional velocity of more than 1,000 meters per second.

2. Each Party undertakes not to flight-test from aircraft cruise missiles capable of a range in excess of 600 kilometers which are equipped with multiple independently targetable warheads and not to deploy such cruise missiles on aircraft.

Agreed Statement. Warheads of a cruise missile are independently targetable if maneuvering or targeting of the warheads to separate aim points along ballistic trajectories or any other flight paths, which are unrelated to each other, is accomplished during a flight of a cruise missile.

Article X

Subject to the provisions of this Treaty, modernization and replacement of strategic offensive arms may be carried out.

Article XI

1. Strategic offensive arms which would be in excess of the aggregate numbers provided for in this Treaty as well as strategic offensive arms prohibited by this Treaty shall be dismantled or destroyed under procedures to be agreed upon in the Standing Consultative Commission.

2. Dismantling or destruction of strategic offensive arms which would be in excess of the aggregate number provided for in paragraph 1 of Article III shall begin on the date of the entry into force of this Treaty and shall be completed within the following periods from that date: four months for ICBM launchers; six months for SLBM launchers; and three months for heavy bombers.

3. Dismantling or destruction of strategic offensive arms which would be in excess of the aggregate number provided for in paragraph 2 of Article III shall be initiated no later than January 1, 1981, shall be carried out throughout the ensuing twelve-month period, and shall be completed no later than December 31, 1981.

4. Dismantling or destruction of strategic offensive arms prohibited by this Treaty shall be completed within the shortest possible agreed period of time, but not later than six months after the entry into force of this Treaty.

Article XII

In order to ensure the viability and effectiveness of this Treaty, each Party undertakes not to circumvent the provisions of this Treaty, through any other state or states, or in any other manner.

Article XIII

Each Party undertakes not to assume any international obligations which would conflict with this Treaty.

Article XIV

The Parties undertake to begin, promptly after the entry into force of this Treaty, active negotiations with the objective of achieving, as soon as possible, agreement on further measures for the limitation and reduction of strategic arms. It is also the objective of the Parties to conclude well in advance of 1985 an agreement limiting strategic offensive arms to replace this Treaty upon its expiration.

Article XV

1. For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.

2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.

3. Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

First Agreed Statement. Deliberate concealment measures, as referred to in paragraph 3 of Article XV of the Treaty, are measures carried out deliberately to hinder or deliberately to impede verification by national technical means of compliance with the provisions of the Treaty.

Second Agreed Statement. The obligation not to use deliberate concealment measures, provided for in paragraph 3 of Article XV of the Treaty, does not preclude the testing of anti-missile defense penetration aids.

First Common Understanding. The provisions of paragraph 3 of Article XV of the Treaty and the First Agreed Statement thereto apply to all provisions of the Treaty, including provisions associated with testing. In this connection, the obligation not to use deliberate concealment measures includes the obligation not to use deliberate concealment measures associated with testing, including those measures aimed at concealing the association between ICBMs and launchers during testing.

Second Common Understanding. Each Party is free to use various methods of transmitting telemetric information during testing, including its encryption, except that, in accordance with the provisions of paragraph 3 of Article XV of the Treaty, neither Party shall engage in deliberate denial of telemetric information, such as through the use of telemetry encryption, whenever such denial impedes verification of compliance with the provisions of the Treaty.

Third Common Understanding. In addition to the obligations provided for in paragraph 3 of Article XV of the Treaty, no shelters which impede verification by national technical means of compliance with the provisions of the Treaty shall be used over ICBM silo launchers.

Article XVI

1. Each Party undertakes, before conducting each planned ICBM launch, to notify the other Party well in advance on a case-by-case basis that such a launch will occur, except for single ICBM launches from test ranges or from ICBM launcher deployment areas, which are not planned to extend beyond its national territory.

First Common Understanding. ICBM launches to which the obligations provided for in Article XVI of the Treaty apply, include, among others, those ICBM launches for which advance notification is required pursuant to the provisions of the Agreement on Measures to Reduce the Risk of Outbreak of Nuclear War Between the United States of America and the Union of Soviet Socialist Republics, signed September 30, 1971, and the Agreement Between the Government of the United States of America and the Government of the Union of Soviet Socialist Republics on the Prevention of Incidents On and Over the High Seas, signed May 25, 1972. Nothing in Article XVI of the Treaty is intended to inhibit advance notification, on a voluntary basis, of any ICBM launches not subject to its provisions, the advance notification of which would enhance confidence between the Parties.

Second Common Understanding. A multiple ICBM launch conducted by a Party, as distinct from single ICBM launches referred to in Article XVI of the Treaty, is a launch which would result in two or more of its ICBMs being in flight at the same time.

Third Common Understanding. The test ranges referred to in Article XVI of the Treaty are those covered by the Second Agreed Statement to paragraph 2 of Article VII of the Treaty.

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2. The Parties shall agree in the Standing Consultative Commission upon procedures to implement the provisions of this Article.

Article XVII

1. To promote the objectives and implementation of the provisions of this Treaty, the Parties shall use the Standing Consultative Commission established by the Memorandum of Understanding Between the Government of the United States of America and the Government of the Union of Soviet Socialist Republics Regarding the Establishment of a Standing Consultative Commission of December 21, 1972.

2. Within the framework of the Standing Consultative Commission, with respect to this Treaty, the Parties will:

(a) consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous;

(b) provide on a voluntary basis such information as either Party considers necessary to assure confidence in compliance with the obligations assumed;

(c) consider questions involving unintended interference with national technical means of verification, and questions involving unintended impeding of verification by national technical means of compliance with the provisions of this Treaty;

(d) consider possible changes in the strategic situation which have a bearing on the provisions of this Treaty;

(e) agree upon procedures for replacement, conversion, and dismantling or destruction, of strategic offensive arms in cases provided for in the provisions of this Treaty and upon procedures for removal of such arms from the aggregate numbers when they otherwise cease to be subject to the limitations provided for in this Treaty, and at regular sessions of the Standing Consultative Commission, notify each other in accordance with the aforementioned procedures, at least twice annually, of actions completed and those in process;

(f) consider, as appropriate, possible proposals for further increasing the viability of this Treaty, including proposals for amendments in accordance with the provisions of this Treaty;

(g) consider, as appropriate, proposals for further measures limiting strategic offensive arms.

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3. In the Standing Consultative Commission the Parties shall maintain by category the agreed data base on the numbers of strategic

Agreed Statement. In order to maintain the agreed data base on the numbers of strategic offensive arms subject to the limitations provided for in the Treaty in accordance with paragraph 3 of Article XVII of the Treaty, at each regular session of the Standing Consultative Commission the Parties will notify each other of and consider changes in those numbers in the following categories: launchers of ICBMs;

APPENDIX X

U.S. Photographic Reconnaissance Satellites

Year	Name		Success ratio	Comments
1959	Discoverers	1-8	nil	2 failed launch 0 returned info.
1960	Discoverers	9-18	20%	
1961	Samos	1, 2	20%	
	Discoverers	20-38		
	USAF	1, 2		
1962	Discoverers	37-38	95%	
	USAF	25 launches		
1963	USAF	20 launches	95%	
1964	USAF	26 launches	98%	
1965	USAF	22 launches	98%	Most were radio transmission type
1966	USAF	24 launches	98%	
1967	USAF	19 launches	98%	
1968	USAF	16 launches	100%	
1969	USAF	12 launches	100%	2 returned to earth and were recovered.

Year	Name		Success ratio	Comments
1970	USAF	9 launches	100%	2 returned and recovered.
1971	USAF	8 launches	88%	Big Bird launched.
1972	USAF	8 launches	100%	3 more Big Birds.
1973		6 launches	82%	
1974	USAF	5 launches	100%	2 Big Birds.
1975	USAF	4 launches	100%	2 Big Birds.
1976	USAF	4 launches	100%	2 Big Birds.
1977	USAF	3 launches	100%	1 Big Bird 2 low resolution.
1978	USAF	2 launches	100%	2 Big Birds
1979	USAF	2 launches	100%	1 Big Bird 1 area surveillance.
1980	USAF	2 launches	100%	2 Big Birds.

Total launches 256 (to January 1981)

Source: Stockholm International Peace Research Institute, Outer Space Battlefield of the Future?, (London, Taylor and Francis, 1978,1979,1980)

APPENDIX XI

Soviet Photographic Reconnaissance Satellites*

Year	# of launches	Comments
1962	5	first generation low resolution.
1963	7	one high resolution.
1964	12	two high resolution.
1965	17	seven low resolution. ten high resolution.
1966	21	nine low resolution ten high resolution.
1967	22	five low res'n seventeen high res'n.
1968	29	25 high res'n 4 third generation ejected capsule.
1969	32	25 high res'n 7 third generation.
1970	29	11 second generation 18 third generation.

*Success rate cannot be accounted for.

Characteristics of satellites are based mainly on observation of satellite orbit.

Year	# of launches	Comments
1971	28	22 third generation 6 maneuverable.
1972	29	28 third generation 1 unclassified.
1973	35	34 third generation 1 unclassified.
1974	28	27 third generation 1 unclassified.
1975	34	33 third generation 1 fourth generation - exploded in orbit.
1976	33	30 third generation 2 second generation 1 fourth generation - improved lifetime.
1977	33	1 second generation 31 third generation 1 fourth generation.
1978	35	11 high res'n 18 low res'n 6 unclassified.
1979	35	1 fourth generation 34 high res'n.
1980	35	31 third generation.

launches.

Source: Stockholm International Peace Research Institute., Outer Space Battlefield of the Future?., (London, Taylor and Francis, 1978,1979, 1980).

APPENDIX XII

Remote Sensing Satellites Other Than Reconnaissance

United States

Year	Electronic Reconnaissance	Early Warning	Ocean Navigation
1960		3	
1961		3	
1962	3	2	
1963	7	5	
1964	8	2	
1965	6	2	
1966	10	3	
1967	8	2	
1968	7	1	
1969	6	3	
1970	4	5	
1971	3	1	
1972	3	2	
1973	2	2	
1974	3		
1975	2	2	
1976	1	1	
1977		1	5
1978	1	2	5
1979	1		1
1980	1		4
	76	42	15

Source: Stockholm International Peace Research Institute., Outer Space Battlefield of the Future?., (London, Taylor and Francis, 1978,1979, 1980).

APPENDIX XIII

Remote Sensing Satellites Other Than Reconnaissance

Soviet Union

Year	Electronic Reconnaissance	Early Warning	Ocean Navigation
1967*	5	2	1
1968	7	1	1
1969	11		
1970	10		1
1971	15		2
1972	7	1	1
1973	12	1	1
1974	10	1	2
1975	7	2	3
1976	9	1	2
1977	5	3	3
1978	2	2	8
1979	2	4	3
1980	2	5	4
Total	102	23	32

*No known launchings prior to this year.

Source: Stockholm International Peace Research Institute., Outer Space Battlefield of the Future? , (London, Taylor and Francis, 1978, 1979, 1980)

BIBLIOGRAPHY

Books

Audet, Herve, et Thompson, Keith. La Teledetection au Quebec. Quebec: Ministre de l'Energie et des Ressources, 1976.

Belitsky, Boris. International Space Law. Moscow: Progress Publishers, 1976.

Bhatt, S. Legal Controls of Outer Space. New Dehli: S. Chand and Co. Ltd., 1973.

Colwell, Robert. Remote Sensing: A Better View. ? : Duxbury Press, 1978.

Cooper, John C. Explorations In Aerospace Law. Montreal: McGill University Press, 1968.

Evans, Carol S., ed. Canada's Aerospace Industry. Toronto: Maclean Hunter Ltd., 1981.

Feldman, George J. Law and Politics in Space. Edited by Maxwell Cohon. Montreal: McGill University Press, 196?.

Frick, R.H. Stability and Control of Translunar Earth Orbits. Santa Monica,Ca.: Rand Corporation, July, 1971.

Gatland, Kenneth. ed., Space Technology. New York: Harmony Books, 1981.

Greenwood, Ted. Reconnaissance, Surveillance and Arms Control. Adelphi Paper #88. London: International Institute for Strategic Studies, June, 1972.

Hackett, General Sir John et al., The Third World War. London: Sidgwick and Jackson, 1978.

Haley, Andrew. Space Law and Government. New York: Appleton-Century-Crofts, 1963.

Harper, Dorothy. Eye In The Sky. Montreal: Multiscience Publications, 1976.

Heaps, Leo. Operation Morning Light. New York: Paddington Press, 1978.

Hochman, Sandra. Satellite Spies. New York: Bobbs-Merill Co. Inc., 1976.

Ionescu, Ghita. Between Sovereignty and Integration. New York, John Wiley and Sons, 1974.

Johnson, D. N. H., Rights in Air Space. Manchester: Manchester University Press, Manchester: Manchester University Press, 1974.

Kroeck, Dick. Everyone's Space Handbook. New Mexico, University of New Mexico, 1976.

Ksander, Yuri. Soviet Chemical Laser Research: Pulsed Lasers. Santa Monica, Ca.: Rand Corporation, November, 1971.

Lay, S. Houston and Taubenfeld, Howard J., The Law Relating to Activities of Man in Space. Chicago: University of Chicago Press, 1970.

McDougal, Myres S.; Lasswell, Harold D.; and Vlasic, Ivan A. Law and Public Order in Space. New Haven and London: Yale University Press, 1963.

McNamara, Robert S. The Essence of Security. New York: Harper and Row, 1968.

Martin, James. Communications Satellite Systems. Englewood Cliffs, N.J.: Prentice Hall, 1978.

Matte, Nicholas, and DeSaussure, Hamilton De. Legal Implications of Remote Sensing from Outer Space. Atcchampij: Sizthoff Uitgeversma, 1976.

Mezerik, A.G., ed. Outer Space, U.N.-U.S.-U.S.S.R., New York: International Review Service (U.N.), 1960.

Miles, Edward. International Administration of Space Exploration and Exploitation. vol. 8, monograph 4, Denver Colo.: University of Denver, 1971.

Morenoff, James. World Peace Through Space Law. Charlottesville, Va.: Mitchie Co., 1967.

Nozari, Fariboz. The Law of Outer Space. Stolkholm: Norstedt and Soners Forlag, 1973.

Ogunbanwo, Ogunsola. International Law and Outer Space Activities. Netherlands: The Hague, 1975.

Onley., David C. Shuttle. Toronto: Futura Publications, 1981.

Porter, Richard W. The Versatile Satellite. London: Oxford University Press, 1977.

Rapp, Robert R. The Effect of Weather on Soviet Wheat Production. Santa Monica, Ca.: Rand Corporation, December 1980.

~Reves, Robert G., ed. Manual of Remote Sensing. 2 vols., Falls Church Va.: American Society of Photogammetry, 1975.

Reiznen, Gizsbertha. Utilization of Space and International Law. Amsterdam: Elsevier Publishing Co., 1981.

Royal United Services Institute for Defense Studies, ed. Rusi and Brassey's Defence Yearbook. London: Royal United Services Institute, 1981.

Rudd, Robert. Remote Sensing: A Better View. Belmont, Ca.: Duxbury Press, 1974.

Salked, Robert. War and Space. Englewood Cliffs, N.J.: Prentice Hall, 1970.

Scoville, Herbert. Can Space Remain A Peaceful Enviroment?. Occassional Paper 18, Muscatine, Iowa: The Stanley Foundation, 1978.

Shternfeld, Ari. Soviet Space Science. Foreward by Willy Ley. Translated by the Technical Documents Liason Office, Wright Patterson Air Force Base, Ohio, New York: Basic Books Inc., 1959.

Shubik, Martin. Games For Society, Business, and War. New York: Elsevier Scientific Publishing Co., 1975.

Smith, Delbert D. Space Stations. Boulder, Colo.: Westview Press, 1979.

Snow, Marcellus S. International Commercial Satellite Communications. New York: Praegar Publishers, 1976.

Stockholm International Peace Research Institute. Outer Space - Battlefield of the Future?. London: Taylor and Francis Ltd., 1978.

Stoiko, Michael. Soviet Rocketry. New York: Holt, Reinhart, and Winston, 1970.

Taubenfeld, Howard and Jessup, Howard. Controls for Outer Space. New York: Columbia University Press, 1959.

Tooke, Moyna, ed. The Common Heritage. Ottawa: The Teachers Press, 1978.

Vazquez, Modesto S. Cosmic International Law. Detroit: Wayne State University, 1965.

Von Glahn, Gerhard. Law Among Nations. New York: Macmillan Co., 1965.

Wyndham Place Trust, ed. Man's Wider Loyalties London, Plutchinson and Co., 1970.

Gorove, Steven, "The Geostationary Orbit: Issues of Law and Policy" American Journal of International Law 73 (July 1979): 444-461.

Gregory, Alan F. "Earth Observation Satellites: A Potential Impetus For Economic and Social Development" World Cartography 11 New York: United Nations Department of Economic and Social Affairs, 1971. Pp. 1-15.

Hasse, Ynez D. "Remote Sensing and Its Applications" Information Bulliten 3 (2) (March 1972). Pp. 25-30.

____________ "How Satellites May Help To Sell SALT." U.S. News and World Report, 15 May 1982, p. 25.

Hudcovic, Edward M. "Remote Sensing by Satellite: Violations of Sovereignty and the Territorial Principle of the Second State" Northrop University Law Journal 1 (1) (Winter 1979): 139-152.

Jensen, Homer et. al. "Side-Looking Airborne Radar" Scientific American 237 (4) (October 1977): 85-95.

Magdelenat, Jean-Louis "The Major Issues in the Agreed Principles on Remote Sensing" Journal of Space Law 9 115

Matte, Nicholas "Space Policy Today and Gomorrow" Annals of Air and Space Law 4 (1979) Montreal: McGill University Press, 1979. Pp. 81-123.

Menter, Martin "Jurisdiction Over Man Made Satellites" Journal of Space Law 2 (Spring 1974): 19-25.

Robinson, George S. "Militarization and the Outer Space Treaty - Time for a Restatement of "Space Law"" Astronautics and Aeronautics 17(2) (February 1978): 26-29.

____________ "Satellite Communications" Encyclopedia Britannica 16 New York, Encyclopedia Britannica, 1975.

Sayn-Wittgenstein, L. "Space Technology Aids the Forest Industry" Revue de L"Ingeniere (December 1980)

Schelling, T.C. "What is Game Theory?" Contemporary Political Analysis. ed. by James C. Charlesworth. New York: The Free Press, 1967. Pp. 212-238.

Shubik, Martin. "The Uses of Game Theory" Contemporary Political Analysis. ed. by James C. Charlesworth. New York: The Free Press, 1967. Pp. 239-272.

Articles and Periodicals

Borhunov, V.D. "Legal Problems of International Cooperation in Remote Sensing" The Twentysecond Colloquium of the Institute of International Space Law New York: American Institute of Aeronautics and Astronautics, 1980. Pp. 103-105.

Brooks, Eugene "Technological and Legal Aspects of Enviromental Monitoring" Journal of Space Law 1 (Spring, 1973): 28-37.

Cheng, Ben "The Legal Regime of Airspace and Outer Space: The Boundary Problem - Functionalism versus Spatialism: The Major Premises" Annals of Air and Space Law 5 (1980) Montreal: McGill University Press, 1980. Pp. 323-339.

Christol, Carl O. "Remote Sensing and International Law" Annals of Air and Space Law 5 (1980) Montreal: McGill University Press, 1980. Pp. 379-420

Detjen, Jim "TRASH-1 May Solve Problem of Space Garbage" Toronto Star, 22 December 1982, p. 36.

Dudakov, B.G. "On International Legal Status of Artificial Earth Satellites And The Zone Adjacent To Them" The Twentyfourth Colloquium of the American Institute of Aeronautics and Astronautics New York: American Institute of Aeronautics and Astronautics, 1981. Pp. 97-101.

Durst, Steve "Canada In Space" Space Age Review 6 (August-September 1979): 188-189.

Galloway, Eilene "Applicability of Space Treaties to the Uses of Outer Space" Annals of Air and Space Law 1 (1976) Montreal: McGill University Press, 1980. Pp. 205-211.

Galloway, Eilene "The Present Status of Remote Sensing in the United Nations" The Nineteenth Colloquium of the Institute of International Space Law New York: American Institute of Aeronautics and Astronautics, 1977. Pp. 499-509.

Garwin, Richard L. "Are We on the Verge of an Arms Race in Space?" Bulletin of the Atomic Scientists 37 (May 1981): 48-53.

Goedhuis, D. "Some Observations On the Problem of the Definition and/or Delimitation of Outer Space" Annals of Air and Space Law 2 (1977) Montreal: McGill University University Press, 1977. Pp.293-309.

Gore, Rick. "When the Space Shuttle Finally Flies" National Geographic 159 (3)(March 1981): 317-347.

_______________ "Soviets Launch Ocean Surveillance Satellite" Aviation Week and Space Technology. 7 June 1982. p. 16.

Vereshchetin, V.S. "On The Principle of State Sovereignty In International Space Law" Annals of Air and Space Law 2 (1977) Montreal: McGill University Press, 1979. Pp. 429-436.

Weaver, Kenneth F. "Remote Sensing: New Eyes to See the World" National Geographic, 35 (1) (January 1969) Pp. 47-73.

Woetzel, Robert K. "Legal Aspects of Military Uses of Space In Soviet and American Eyes" Space and Society ed. by Howard Taubenfeld. New York: Oceana Publications, 1964. Pp. 121-139.

Wolfe, Tom. "Columbia Closes A Circle" National Geographic 160 (4) (October 1981) :474-503.

Government Documents

Aldofi, Thomas T., and Harvie, Julia M. Smoke Plume Definition by Satellite Remote Sensing. A publication of the Canada Centre for Remote Sensing. Users Manual 81-3. Ottawa: Energy, Mines and Resources, 1981.

Canada, Knowing Weather. A publication of the Atmospheric Enviroment Service. Ottawa: Enviroment Canada, 1982.

Cihlar, Josef. CCRS Airborne Program Assessment: Volume 1 - Analysis. A publication of the Canada Centre for Remote Sensing. Research Report 78-3. Ottawa: Energy, Mines, and Resources, 1978.

Canada, Department of External Affairs, Annual Report. Ottawa: Department of External Affairs, 1980.

Interdepartmental Task Force on Surveillance Satellites. Satellites and Sovereignty. Ottawa: Energy, Mines, and Resources, 1977.

Canada, The Canadian Space Program for 1982/83 - 1984/85. Ottawa: Minister of State for Science and Technology, 1981.

Ryerson, Robert A. Land Use Information From Remotely Sensed Data. A publication of the Canada Centre for Remote Sensing. Users Manual 80-1. Ottawa: Energy, Mines and Resources, 1980.

Tracy, Nicholas Canada's Foreign Policy Objectives and Canadian Security Arrangements in the North. Operational Research and Analysis Establishment. Ottawa: Department of National Defense, 1980.

Unpublished Sources

Colwell, Robert N. Monitoring Earth Resources from Aircraft and Spacecraft. NASA Special Publication 275. Washington D.C.: NASA, 1970.

________________ "Eye In The Sky - A Versatile Tool" Computing Canada. November 11, 1980.

Goldschlag, K. "The Notion of Sovereignty in an Evolving World System" An Address to the Canadian Institute of International Affairs on the occassion of its fifthiest anniversary. Toronto, Canadian Institute of International Affairs, 1978.

McCormack, Martin. "Ionospheric Satellites" The Mirrored Spectrum Copy of an extract by Information Canada. Ottawa: Information Canada, 1974.

Minnich, Mike amd Messer, Tom "Airborne DP Aids Remote Sensing" Canadian Datasystems March 1981.(Extract)

Nyiri, N. Alternatives to Nuclear Warfare: A Possible Role for Canada in the US/USSR Nuclear Balance. 2 vols. (Occasional Paper #2) Waterloo: Waterloo Lutheran University, 1971.

Spar Aerospace. Radarsat Ste-Anne-de-Bellevue, Quebec: SPAR Aerospace, 1981.

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