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Satellite warfare
A challenge for the international community

Report by the French Institute for International Relations (IFRI) prepared under the direction of Pierre Lellouche

With the collaboration of: Yves Boyer, Eva Kulesza and Jérôme Paolini

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NOTE

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PREFACE

The United Nations Institute for Disarmament Research (UNIDIR) which has been in existence since October 1, 1980, was established by the General Assembly as an autonomous institution within the framework of the United Nations to carry out independent research on disarmament and related international security issues.

The work of the Institute, which is based on the provisions of the Final Document of the Tenth Special Session of the General Assembly, aims at:

Providing the International community with more diversified and complete data on problems relating to international security, the armaments race and disarmament in all fields, particularly in the nuclear field, so as to facilitate progress, through negotiations, towards greater security for all States, and towards the economic and social development of all peoples;

Promoting informed participation by all States in disarmament efforts;

Assisting on-going negotiations on disarmament and continuing efforts to ensure greater international security at a progressively lower level of armaments, particularly nuclear armaments, by means of objective and factual studies and analyses;

Carrying out more in-depth, forward looking and long-term research on disarmament so as to provide a general insight to the problems involved and stimulating new initiatives for new negotiations.

Paragraph 80 of the Final Document of the Tenth Special Session of the General Assembly, addressing the subject of the prevention of an arms race in outer space, calls for new measures to be implemented and appropriate international negotiations to be undertaken in conformity with the spirit of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space Including the Moon and Other Celestial Bodies. In that context UNIDIR is glad to publish this study undertaken by the French Institute for International Relations (IFRI) under the direction of Pierre Lellouche, with the collaboration of Yves Boyer, Eva Kulesza and Jérôme Paolini, assisted by a special working group of leading French experts on outer space. Starting from the premise that outer space is being utilized by the two great space Powers primarily for military purposes, the authors contend that the further development of ASAT weapons would introduce "a major element of uncertainty into the strategic equation" between them. Avoidance of this new danger is the stated objective of the study.

In order to achieve their purpose, the authors explore the nature of the ASAT threat to international security, taking into account the likely interaction between those weapons and the possible introduction of anti-missile space defences. Giving full weight to the problems posed by the vast array of possibilities for causing damage to objects in space, the study concentrates on a search for means to ensure the safety of satellites. Many concrete proposals are advanced within the context of a recommendation to establish an international space agency.

The issues dealt with here are among those of the greatest significance for the security of all States and the subject matter has been approached with due regard to its indisputable importance. Although UNIDIR takes no position on the views and conclusions expressed by the authors of its studies, it does assume responsibility for determining whether a work merits publication and hence commends this study to the attention of its readers.

Jayantha DHANAPALA
Director, UNIDIR

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FOREWORD

Thirty years after the launching of the first Sputnik satellite, the exploration of space has become a challenge of major importance for the international community as a whole. Civil applications such as telecommunications, meteorology, television and remote Earth sensing are by now part and parcel of everyday life for a large proportion of mankind, and the number of nations with space ambitions is constantly growing, both among the developed regions (Europe and Japan) and also in the developing parts of the world (India and China in particular).

But whether we like it or not, this civil and industrial dimension of space represents only a minor aspect of the matter in terms both of financial investment and of the placement of space objects. The truth is that space has become first and foremost a theatre for tough military competition between the two super-Powers. In these two countries, military space budgets are far and away greater than the investments earmarked for the civil sector, and more than three-quarters of the launchings carried out today are for military purposes.

Since one wrong move leads to another, the growing importance of space systems as part of the military machinery of the two great Powers—for functions as basic as reconnaissance, military communications, early warning systems or electronic data—has made these space installations ideal targets for strikes by the other side. Hence the appearance of anti-satellite weapons systems (ASAT), on both the Soviet and the American side, designed specifically to destroy the military platforms the moment hostilities begin. Thus, the adversary would find himself attacked at his nerve centre even before the first shot had been fired on the ground.

The development of ASAT weapons not only introduces a major element of uncertainty into the strategic equation between the two great Powers, it also brings with it serious consequences for all the other users—essentially civil users—of space. The latter find their space installations potentially threatened by ever larger numbers of military systems deployed by the two great Powers, and also threatened by the possible introduction of operational ASAT systems. This risk is all the greater today inasmuch as the possible introduction of anti-missile space defences would inevitably bring about the deployment of counter-measures, for example in the form of ASAT weapons.

It is precisely an analysis of this threat and of ways and means of removing it that constitutes the subject of the present report, prepared by IFRI for the United Nations Institute for Disarmament Research. As we shall see, the ASAT problem is extraordinarily difficult to circumscribe, because of the enormous diversity of types of possible interference against space platforms (ranging from "soft" aggression, unobtrusive and not easy to detect, designed to cause gradual damage to the electronic devices on the target satellites, through "killer satellites", to interceptors loaded on board planes or on other satellites). Similarly, ways and means of halting the proliferation of ASAT systems, and particularly of controlling their effects on space installations belonging to third Powers, are equally difficult to define, if we bear in mind the inadequacy of the legal régime existing today in space matters, and the difficulties, particularly in regard to verification, inherent in the space environment.

In carrying out this highly technical study, the IFRI research team was fortunate enough to have at its disposal, in the context of a working group convened specially for the purpose throughout 1986, the expertise of the leading French experts on space. A list of members of this group is given in this volume. The list is deliberately not exhaustive, but I would nevertheless like here to thank each of the persons, whether mentioned by name or not, for the time and knowledge they have so generously been willing to contribute to this genuinely collective effort. I would also like in particular to thank Serge Sur and Jacques Battistella for the excellent written contributions they have made to the group's work. It goes without saying that the conclusions reached and the analyses made in the report only commit the writers on the IFRI research team, and not the experts consulted or the administrations and undertakings for which they work.

It is now for the reader to appreciate the extent of the problem and to reflect, starting from the recommendations made at the conclusion of this report, on methods for establishing a more orderly, and let us hope more peaceful, régime for the utilization of space to the benefit of all.

Pierre LELLOUCHE
Paris, February 1987

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Introduction

THE CHALLENGE OF SPACE FOR THE INTERNATIONAL COMMUNITY

The date of 4 October 1987 marked the thirtieth anniversary of the launching by the Soviet Union of the first artificial satellite from the Earth, inaugurating the era of the conquest of space. At the time, very few observers would have ventured a guess as to the number and variety of developments that this enterprise was to bring about, let alone the scientific impact it was to have on the very way in which we perceive our own planet. Civil space activity, initially the "fall-out" from military research and programmes, has none the less rapidly followed an evolution of its own since the mid-1960s. Its development has had the effect of making it possible to exploit on an intensive scientific and commercial scale the unique opportunities offered by the new milieu to the international community as a whole.

Before sketching the main outlines of this evolution, which has radically dictated the shape of civil space applications, it may be well to refer to two vital consequences of it. First of all, whereas most of the military uses of space are still confined to the Soviet-American duopoly, civil activities have rapidly been extended to a growing number of users and participants. Secondly, the emergence at the beginning of the 1980s of a small but energetic space industry sector has led the more advanced States to become aware of the advantages in international competition of mastering new technologies and to encourage the peak sectors in the field of space activity. A situation more and more marked by the increasing competitive commercialization of space services thus indirectly helps to facilitate the access of the various members of the international community, whatever their level of development, to new space applications.

The scientific exploration of the cosmos

The first and most fundamental achievement of the space adventure is the outcome of the scientific missions which by means of space probes and automatic space vehicles have systematically explored the heavenly bodies in the immediate environment of our planet. Since the discovery of the Van Allen radiation belts by the first American Satellite Explorer I in January 1958, and the first photographs of the dark side of the moon transmitted by the Soviet Luna-3 (nicknamed *Lunik* at the time) in October 1959, the opportunities for observation and analysis given by space vehicles have produced a veritable astronomical revolution. The harvest of vital scientific data thus garnered over the last 20 years or so has not only turned our knowledge of the solar system upside down; it also makes it currently possible to anticipate an understanding of the history and perhaps even the origin of that system. All the planets in the solar system (with the exception of the one furthest away, namely Pluto) have thus been successively explored by overflights or even landings by American or Soviet probes. Two American scientific spacecraft, Pioneer XI and Voyager X, were the first man-made objects to go beyond the frontiers of the solar system, and today they are encroaching on the immensity of the universe. But the future no doubt holds in store feats which will go beyond anything that has been accomplished up to the present in the field of exploration of the cosmos. The systematic use of means of observation from the Earth's orbit will free astronomy from the shroud constituted by the atmospheric cover of our planet, and will give man access to an extremely varied field of observations of the whole of the electromagnetic spectrum. Many satellites will thus make it possible to extend the field of analysis to higher wavelengths (infra-red and radio) or lower (ultra violet, X-ray and gamma ray). But perhaps the most important scientific instrument ever placed in space will be the great Hubble space telescope, which should be placed in orbit with the resumption of flights by the American space shuttle in March 1988. From an altitude of 600 km, this large 13 metre-long structure, weighing some 12 tons, should be able to place at the disposal of science a volume of observations 350 times greater than the best land observatories, with a resolution 10 times more refined. Described as "the greatest astronomical event since Galileo", it should make it possible to pinpoint the age and the size of the universe, to understand more clearly the phenomena which led to the formation of the stars, and for the first time to determine the probability of the existence of other planetary systems comparable to our own solar system.

The development of the study of terrestrial phenomena

Spectacular though they may be, the successes and prospects of the disinterested scientific exploration of space none the less conceal a reality which has become steadily more insistent since the beginning of the 1970s, namely the relative relegation into the background of basic astronomical research as compared with scientific activities directed towards the study of the Earth and terrestrial physical phenomena. The first steps taken by man on the Moon on 21 July 1969 were in this sense an epoch-making event, inaugurating a new period in space adventure. Less sensitive than in the past to arguments of prestige, and concerned henceforth about economic cost rather than about fundamental scientific findings, the nations of the world are henceforward likely to devote their space programmes essentially to activities in the zone immediately surrounding the Earth.

Thus programmes for exploring the solar system, and the expenditure allocated to manned flights, have been substantially reduced in favour of activities with findings more directly applicable to earthly needs. This new, pragmatic approach, bound up among other things with limitations in financial capacity imposed by severe inflation during the 1970s, has profoundly influenced the recent development of civil space activity. For reasons of economy, the United States definitely put an end to the Apollo programme in 1973 after only six landings on the Moon. Apart from the relative success of the first Skylab space laboratory, no manned American flight took place between 1975 and the orbiting trials of the space shuttle beginning in April 1981. Nor is the latter intended for probing deep into space, but constitutes rather a carrier vehicle essential for performing orbiting activities, pending the construction of a permanent space station which should see the light of day by the beginning of the next decade. As regards the Soviet space programme, once it abandoned the race to reach the Moon, which put the seal on America's technological supremacy, it started along the same road as the United States, but using a strangely antithetical approach. Taking advantage of their tested capacity for conventional non-recoverable launchings, the Soviets have been engaged since 1971 in a vast space station undertaking with Salyut and Mir and the Progress cargo devices, preferring to postpone until later (till the end of the 1980s) the establishment of a shuttle-type space transport system.

The exploration of the cosmos has, as it were, reached its practical limits with the advent of an era of utilization and exploration of inner orbital space through satellites directly linked to human activities on Earth. On an average, of 100 or so civil cargoes put into orbit between 1975 and 1980, some 20 were intended for scientific missions but only five for the study of the universe. In this respect, the recent international co-operation in connection with the study of Halley's Comet constitutes an exception.

Nowadays, civil applications concerned first and foremost with the study of terrestrial phenomena have rapidly taken on considerable importance for the international community as a whole. The launching of satellites on the geo-stationary arc has made it possible to collect a reliable and regular mass of data of the most diverse kind which, in conjunction with the constant progress of the electronics revolution and analytical data processing by computer, has radically transformed the methods of adapting and forecasting activities on Earth in relation to phenomena which hitherto had been extremely difficult to comprehend. Two domains of scientific application in particular have led to remarkable progress, the impact of which is very important, particularly for developing countries.

The regular transmission of photographs and hydrodynamic analyses via geo-stationary meteorological satellites has over the last 20 years or so revolutionized all the climatic forecasting techniques. This space application has made it possible for the first time to understand climatic phenomena on a really planetary scale, and gradually to work out methematical models of the movements of the atmosphere for long-term weather forecasting. Active international co-operation has led to a generalization of free access to the data compiled by satellite under the aegis of the World Meteorological Organization, a United Nations specialized agency. WMO's "World Weather Watch" thus brings together a wide variety of sources of information from American, Soviet, European, Japanese and even Indian satellites, processes the data and diffuses them internationally. With the help of systems of multi-spectral photographs sensitive to chlorophyl green, the American NOAA meterological satellites have since 1982 produced images which are used for the surveillance of vegetation and crops, determining their density and strength. By this means, crop charts are established every month, enabling the impact of climatic and seasonal changes on agriculture to be evaluated on a national or regionals scale.

More than 125 countries have had ground reception stations installed for widespread, instantaneous diffusion, free of charge. In short, this progress, directly bound up with space technology, facilitating agricultural forecasting through the understanding of phenomena such as drought or deforestation in the most underprivileged regions of the world, greatly enhances the hope of overcoming the difficulties faced by many developing countries.

The second scientific application of space technology to the study of terrestrial phenomena is the launching, since the beginning of the 1970s, of teledetection satellites. The American LANDSAT series of satellites, developed in the framework of military reconnaissance and observation programmes, have since 1972 been furnishing complete continuous and repetitive photographic coverage of the entire globe. Thus they make it possible to produce the time series used in an extremely wide variety of fields of application, from the follow-up of the main trends of the biomass, passing through the study of ocean currents to the detection of national natural resources. A dozen LANDSAT reception stations have been installed round the world. The World Bank, for example, has financed the establishment at Nairobi (Kenya) of a fully-fledged centre for processing images, to which all African users can have access. The fourth satellite of the LANDSAT series was launched in 1982, but no equivalent Soviet system has seen the light of day so far. In the sphere of visible teledetection, infra-red and radar, many projects are under way in Europe, Canada, Japan, India, Brazil and the Soviet Union. Specialist programmes have been launched, such as GEOS for the study from space of the movements of tectonic plates and the deformation of continents, or SEASAT for the oceanographic observation of interaction between large ocean masses. By integrating the whole of the data collected by meteorological and teledetection satellites, as well as by aircraft and through topographical measurements of all descriptions, many countries and international organizations will be able from now on to face more effectively the forecasting difficulties in regard to the environment and natural resources, particularly in the regions less well endowed with basic infrastructures. Thanks to this technological progress by space science reoriented towards direct territorial applications, the understanding of ecosystems must be regarded as a major advance benefiting the international community as a whole.

The opening-up of space to the international community

Once the initial experimentation stage is over, technological advances have always exerted a guiding influence on the development of commercial activities and have thus spread rapidly everywhere. The domain of space has not escaped this logic of progress. In the wake of an evolution which over a quarter of a century redirected itself towards matters directly applicable to terrestrial needs, space in the 1980s is circumscribed, apart from the purely scientific achievements already referred to, by two basic factors.

First of all, these space activities are today a challenge for all of us. Because of the increasing number of participants contributing directly or indirectly to their development or benefiting from their unique attributes, civil space applications actually have attained worldwide dimensions. Furthermore, a dynamic space industry is beginning to emerge in a situation of more and more open international competition, and is becoming involved in the commercial exploitation of space while taking advantage in turn of the possibilities of access to and openings for innovation in new services.

Three access routes to the effective use of satellites for civil and commercial ends are feasible according to the capacities and needs of States at very variable stages of technological advancement.

The first, and the most exacting from the overall logistic point of view, is the work of those countries which alone have acquired a sufficient industrial and technological basis to enable them to undertake autonomous experimentation and operational launchings. The volume of the investment costs for placing objects in orbit, the complexity and length of the production cycles of the essential infrastructures, and the high level of the technical services required, have turned space industry into a prime sector par excellence. All these factors taken together have helped to limit the number of space Powers to a small group of the more advanced countries. The Russian-American duopoly of satellite-launching capacity, which for a long time was predominant, has more recently been challenged, while other countries, individually or in group efforts, have succeeded in putting their own space vehicles into orbit themselves. Thus France, in 1965, was the first country to follow the Soviet and American example, and the creation of the European Space Agency, 10 years later, put an end to Europe's trials and tribulations in the matter. The first successful firing of a European launching vehicle of international class, Ariane, took place in December 1979. In Japan, the National Agency for Space Development (NASDA) has since 1970 been using a launching vehicle, mainly American in concept, which has been replaced today by a national model whose first test flights were carried out in January 1986. With 21 launchings of its own by the end of 1981, Japan has taken third place as regards the total number of objects placed in orbit (after the United States and the Soviet Union, which even today are responsible for more than 80 per cent of launchings each year), and will probably become a leading space Power as time goes on. Finally, the People's Republic of China in 1970, and India in 1980, have joined the club. More remarkable still, these two countries have since then on several occasions achieved launchings into geo-stationary orbit.

Thus the evanescent duopoly of the early years of the conquest of space have been replaced by an oligopoly of six genuinely autonomous space Powers, whose stage of development is nevertheless very variable and is directly linked to the commitment of the public authorities in regard to the financing, development and production of the infrastructures and materials indispensable for direct participation in activities bound up with space.

The second access route available to users of the space sector involves the acquisition of satellites and launching services from American or European industries, within the framework of new marketing procedures. Until the beginning of the 1980s, the United States was virtually the only country to export products and services in this field. Since then, a multipolar trading system has been gradually introduced, although the segmentation of markets and the location of public orders are still preponderant. The extremely flexible nature of marketing gives States the opportunity to tackle the acquisition of space materials at different levels, according to the nature of their needs, their financial capacity, and their relative stage of development. Canada has been a pioneer in this field, producing the first national satellite, Alouette, while making use since September 1962 of the launching services provided by the United States. Other countries, such as Indonesia, Brazil, Australia, Luxembourg and the Arab League States, with less mastery over—or simply desiring to avoid—the delays involved in constituting prime sectors, have resorted to the purchase of satellites from European or American constructors, also borrowing foreign launching vehicles for their satellites. These countries are nevertheless the owners of considerable space segments, and are participants in and fully-fledged beneficiaries of space exploration. In this connection, the allocation of electro-magnetic frequencies and satellite positions on the geo-stationary orbital arc at the administrative conferences of the International Telecommunication Union is the subject of genuine diplomatic negotiations in which more than 150 States take part—a proof of the universal nature of civil space applications.

Finally, a third access route, undoubtedly the most important as regards the number of countries choosing it, is through participation in intergovernmental international organizations specializing in space services. These organizations have gradually come into being in close relationship with the beginnings of marketing in this field. Apart from the outstanding achievements of WMO, which have today culminated in a virtually global meteorological coverage of the planet, the most extensive participation is that of space telecommunications by satellite, which has made it possible within 20 years to set up a world-wide network supplemented by numerous specialized sub-applications. The establishment of multilateral inter-State bodies has provided an organizational framework particularly well adapted to essentially transnational activities where each State can take part in accordance with its needs and capacity, financing part of the overall system in proportion to the level of participation it desires. Closely related to the appearance of competitive markets characteristic of the space sectors emerging in the 1980s, telecommunications by satellite represent the most whole-hearted transition from the initial scientific exploration to present-day commercial exploitation.

The beginnings of commercialization of space services

This commercialization of the civil uses of space, still in its infancy, marks a gradual withdrawal of government commitments decisive for the generation and development of such activities. Although public financing still to a large extent constitutes the essential motivating force in the key sectors, three essential factors are gradually leading towards an international opening-up of the markets.

In the first place, the way has been largely opened up because of the phase of reorientation of scientific space activities towards the study of terrestrial phenomena, which has clearly demonstrated the feasibility and reliability of certain essential applications. Secondly, potential markets particularly suited to these applications have emerged because satellites in orbit were more easily able to meet the demand than any other existing system on the ground. The extraordinary surge of telecommunications and telediffusion by satellite is ample testimony to the importance of this factor. Thirdly, the wave of deregulation of many sectors of the American economy since 1978 has given a great international boost, with vast consequences, particularly to communications, by stimulating competition and lifting regulatory restrictions which hampered the opening-up of markets.

Characteristic of the present stage in the development of the commercialization of space services is that it brings into perspective two intrinsically linked dimensions. First, that of direct applications and systems, now at the exploitation stage, which are undergoing rapid growth, stimulated by international demand emanating essentially from the private sector. Second, that of technological or economic achievements engendered by the development of new industrial products.

The large-scale use of satellites for telecommunications must be regarded as the primary application. It is the only one nowadays which represents real industrial and commercial enterprise of international scope based on space technology. Compared with the classic terrestrial links, Hertzian-wave bundles or coaxial cables, transmission by satellite offers very flexible solutions to the problems of long-distance communication. It is adaptable to the growing diversity of needs of international users, and it also makes for reliable and effective links in zones with sparse populations or in developing countries, saving on the time and cost inherent in the installation of vast land infrastructures. A market with a good deal at stake and expanding rapidly has been set up in this sector because of the wholesale explosion of needs in regard to the telephone over the last 15 years or so. It is thought that nearly 200 telecommunication satellites are likely to be launched into geostationary orbit by 1990 to meet the demand for circuits, particularly in the most dynamic market, the North Atlantic, where this demand is progressing at a sustained rate of 15 per cent per annum since 1975. Geostationary launchings should of themselves alone amount to 23 satellites during the same period, including eight American satellites, four belonging to international organizations and 11 country launchings (not including the socialist countries). This virtually continuous growth has made steady progress possible in the matter of cost: over the last 10 years, the satellite transmission capacity for telecommunications has doubled every four years, and the improvement in output has meant a substantial reduction in tariffs from $32,000 in 1965 to $4,680 in 1980 for a semi-circuit rental. The fall in costs of materials for satellites has run parallel with that of services rendered, thus permitting the development of growing competitiveness.

Whereas in the near future, the employment of highly-advanced technologies promises to revolutionize space telecommunications—a narrow laser cluster one-millionth of a degree wide should be able to transmit the complete text of a world encyclopaedia in less than a second—the very structure of the markets is today undergoing an unprecedented upheaval. Telecommunications using space have evolved in a peculiar manner, in contrast with the other classic land communication media. Satellites in orbit almost immediately enabled telecommunications to be extended on a world-wide scale, specialization within this world network having only come about over the past few years. INTELSAT, a multilateral inter-State body in which some 109 member States take part, thus accounts for 75 per cent of the intercontinental telephone traffic and virtually all televised transmissions, serving a total of 165 countries. In addition, INTELSAT furnishes 33 countries with telecommunication services of a strictly national nature, thus enabling them to make considerable internal economies. With the Soviet Union as their pivot, several socialist countries have set up a similar organization, INTERSPUTNIK, which so far has only about 100 circuits in orbit.

Practically any type of numerical data can today be dispatched by satellite, which has given birth to many new services: direct telediffusion, transmission between computers, telecon, links with mobile elements, educational and medical television. Other organizations have sprung up to meet the demand in these new sectors, on a multilateral basis (e.g. INMARSAT, which links together more than 2,800 ships over all the seas of the world) or on a regional basis (e.g. ARABSAT between States of the Arab League, EUTELSAT in the European framework, or PALAPA for Indonesia and the neighbouring States of South East Asia). The importance of these organizations as an access route to the civil uses of space has been mentioned. They are calculated to make a large contribution towards converting space communications into a sphere where the whole of the international community is faced with a challenge with stakes positively universal in their dimensions.

Other direct applications of space technology are opening up little by little to competition through the development of initiatives and methods of management comparable to those of the private sector; but dependence on public budgets and the still very static nature of the markets contrasts strongly with the dynamic nature and diversification already shown by satellite telecommunications.

The most promising field at the present time is space teledetection, with the gradual privatization of the American system LANDSAT, since 1984 in the hands of a private company, EOSAT, which is hoping this year to embark on the distribution of photographic data on a wider commercial basis. Furthermore, the United States will soon no longer be the only country to furnish images and information collected by teledetection, thanks to the launching in February 1986 of the French SPOT satellite with improved resolution, and the creation of a suitably adapted marketing and distribution corporation known as SPOT-Image. Farmers, mining or oil drilling companies, as well as a wide variety of other users, constitute a potential market here, although up to the present it has not been sufficient to enable this activity to cover its running costs, which are therefore largely financed by national space agencies.

A large number of kindred services supplement this progressive commercial opening up of space exploitation for civil purposes, boosted by the extraordinary stability of economic development in the telecommunication sector. A half-hearted evolution in this direction would appear to be going on in the field of launching services since the creation of the Arianespace Company by the European Space Agency in 1980, with a view to taking over the production and management of European launching vehicles on a commercial scale. In the United States, similar transfers of part of the responsibility for the main national launching body, NASA, through trading procedures, have over the past few years culminated in the establishment of private space transport companies such as Space Service Incorporated. The loss of the space shuttle *Challenger* in January 1986 will actually in the long run have helped to speed up this movement, since the space transport system will from now on have to devote itself exclusively to scientific and military missions, while commercial lauchings will be carried out through disposable devices, under the responsibility of private bodies.

Finally, the land segment market, in other words the construction of ground stations essential for follow-up and linking with satellites in orbit, has just recently expanded in an unprecedented manner directly bound up with the extraordinary diversification of telecommunication services. Infrastructures and terminals for telemetry, pursuit and control are experiencing a huge demand, in the neighbourhood of 35 per cent annual growth. Fierce international competition is appearing at present in the sector of small-scale individual receiving equipment in the expectation that direct telediffusion by satellite will become general. All in all, under the main motivating drive of the telecommunications sector, which today is still in the forefront of international competitiveness, commercial space operations round about the middle of the 1980s has boldly embarked on an era of intensive exploitation of the amazing physical properties offered by the new orbital environment.

Apart from direct applications, the use of technologies developed in the context of space programmes can engender a considerable industrial fall-out in the form of derivative sub-products. The economic interests at stake are directly proportionate to the size of the budgets earmarked for launch vehicles or satellites. The classic example is NASA, which in 1965-1966 (admittedly during the maximum financing period for the Apollo programme), employed some 400,000 persons in the industry. Meanwhile, it is reckoned that all the space expenditure at the time has given an economic return up to 1987 of 7 to 1. More recently in Europe, work on the launcher Ariane 1, the first and the smallest of the family, represented for each model ordered 1 million working hours, or 2,500 persons employed in France, on the basis of five launchings a year. Between 1980 and 1983, French space effort was reflected in an increase in the personnel strength employed in all space activities (industry, research and administration) from approximately 8,000 to approximately 12,000 persons.

Apart from this considerable economic and social dimension, the products derived from space technology have for a quarter of a century formed the basis of the permanent transformation of data processing and communication methods. The earliest space programmes thus furnished an almost unlimited financial back-up for performing modern electronics based first on transistors, then on semi-conductors, which appeared from 1948 onwards in the guidance systems of the first long-range missiles. Since then, the aerospace industry has always been at the forefront of progress in electro-optics. Another important development arising out of research in the space field is the physics of materials, which has also made exceptional progress. The conquest of the Moon, and the intensive utilization of space applications which followed, made for innovations in the field of structures resistant to extreme pressures and temperatures while remaining light and modular. The entirely new generations of metal alloys and composite materials resulting therefrom have literally transformed the whole range of insulation techniques and have found industrial and commercial uses which affect virtually all economic sectors today. With the growing exposure of the markets to international trade, characteristic of the opening-up of space services to commercialization, these various findings add weight to the commercial implications of national policies. Far from losing its former status, the financing of research and development by Governments has become a key tool in a type of competition which is gradually acquiring world dimensions.

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Thus, nearly 30 years after the launching of the first artificial satellite, between scientific exploration and commercial exploitation, space has undoubtedly become a major challenge for the whole of the international community, both because of the diversity of its applications and because of the universality of the participants and the beneficiaries. It seems vital, however, to recognize that civil and peaceful developments represent only a small percentage of the uses of space. Since 1957, outer space has continuously been the target of growing militarization, and military satellites today account for approximately 70 per cent of space activities.

The militarization of space is bound up intrinsically with the actual development of space activities. The appearance and perfecting of techniques that make access to space possible—namely the development of launching platforms capable of putting man-made devices into orbit—has been the outcome of studies and research pursued in the field of ballistic missiles.

This basic linkage between military and space technology constitutes the essence of one of the most noteworthy aspects of the present debate on the military uses of space: the question of anti-ballistic missile (ABM) defence incorporating devices deployed in space. The main lines of the problem, re-stated in March 1983 in President Reagan's SDI speech, are well known. Hence, so as not to go beyond the bounds of the present report devoted to anti-satellite systems, we shall confine ourselves here to drawing attention to the vulnerability of the space component of such anti-ballistic missile devices to possible attack by ASAT weapons.

The growing role of military missions entrusted to space systems—reconnaissance, observation, communications, early warning, navigation—and the increase in the numbers of military satellites (about 100 each year for the USSR and about 10 for the United States, the difference being explained by the longer lifespan of the American satellites) are helping to pose more and more acutely the problem of the security of satellites. It is in response to the importance of the latter for optimizing the strategic attitudes of the Powers to whom they belong, that the concept of the anti-satellite system has made its appearance.

The question of the anti-satellite threat, confined for a long time to the United States and the Soviet Union, the only space Powers which had fully integrated the military applications of space into their security systems and possessed operational ASAT devices or were on the point of possessing them, is likely to take on greater and greater importance. In the first place, further countries (China, France, the United Kingdom) have begun to acquire their own military satellites. Secondly, it is to be feared that the deployment of the ASAT devices already existing and the development of new anti-satellite action techniques (laser weapons or particle bundle weapons in particular) will very soon create a real danger for the safety of so-called "third party" satellites, i.e. all the civil and military satellites of the countries which do not possess ASAT. In this respect, the problem of anti-satellite systems is from now onwards a matter of concern for the whole of the international community.

What is, today, the real significance of the ASAT threat? Which of the two Powers, the USSR or the United States, is ahead today in this field? Does the legal régime regulating the space activities of States reflect the challenge which anti-satellite systems represent? Is it possible to set up an international régime which is likely to reduce the ASAT danger? The following chapters will try to reply to this series of questions.

Chapter I

THE ANTI-SATELLITE THREAT

1. The vulnerability of satellites

Active or passive measures designed to prevent access to information compiled or carried out by an artificial satellite are the outcome of extremely complex operations. They imply highly diversified devices, of which anti-satellite weapons as such are only one component. The use of these weapons has at present only a partial application limited to certain orbits in which the satellite to be destroyed is situated.

The orbit described by a satellite is still at the present time one of the main parameters for determining the degree of vulnerability to an ASAT attack. We distinguish five main types of orbit.

Low orbit

The satellite revolves at an altitude of between 150 and 1,500 km round the Earth. According to NORAD (North American Air Defense), of the 4,600 man-made objects inventoried in space in 1982, 85 per cent were located in this orbit.

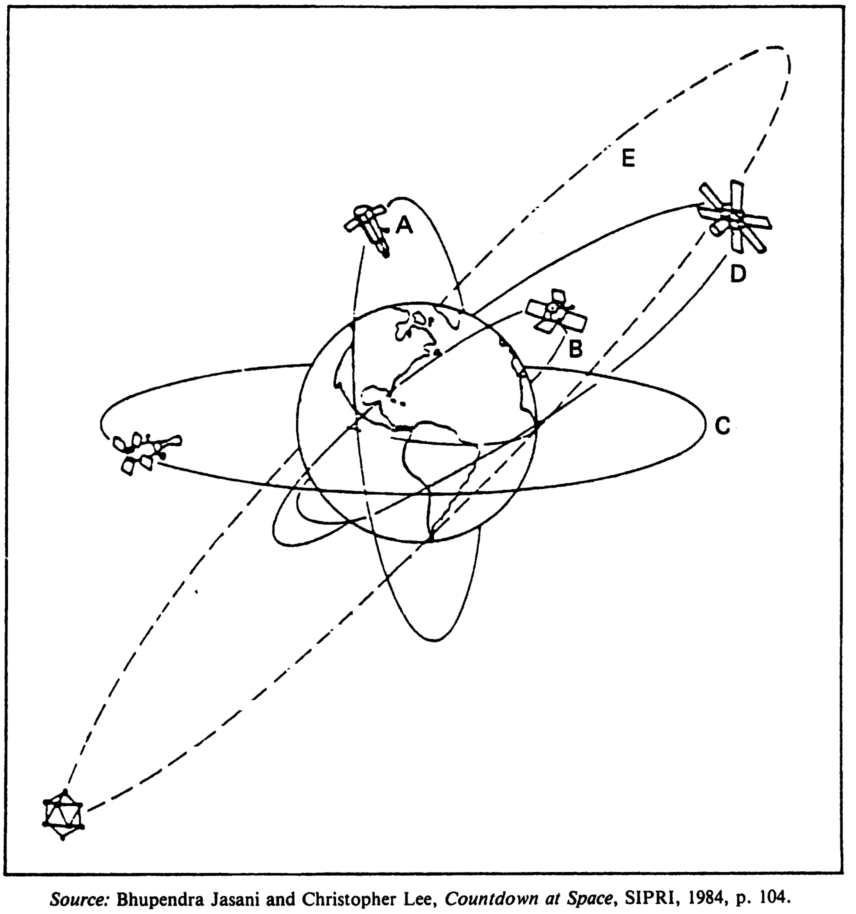
Heliosynchronous orbit

A heliosynchronous orbit is an orbit whose plane precesses by one degree a day around the line of the poles, thus keeping the same position in relation to the Earth-Sun line. There is in fact a whole family of geosynchronous orbits with an inclination of the plane

FIGURE I

Different types of orbit

A = Low polar orbit
B = Heliosynchronous orbit
C = Geo-stationary orbit
D = Molniya orbit (400 km/40,000 km)
E = Very high altitude orbit (110,000 km)



Source: Bhupendra Jasani and Christopher Lee, *Countdown at Space*, SIPRI, 1984, p. 104.

of the orbit in relation to that of the equator which depends on altitude. Typically, these orbits have an inclination of approximately 100° (quasi-polar retrograde orbit) and an altitude of about 800 km.

The orbits of navigation satellites

These are NAVSTAR (American satellites) and GLONASS (Soviet satellites). These are "12-hour" virtually circular orbits at 20,000 km in altitude and 65° inclination towards the equator.

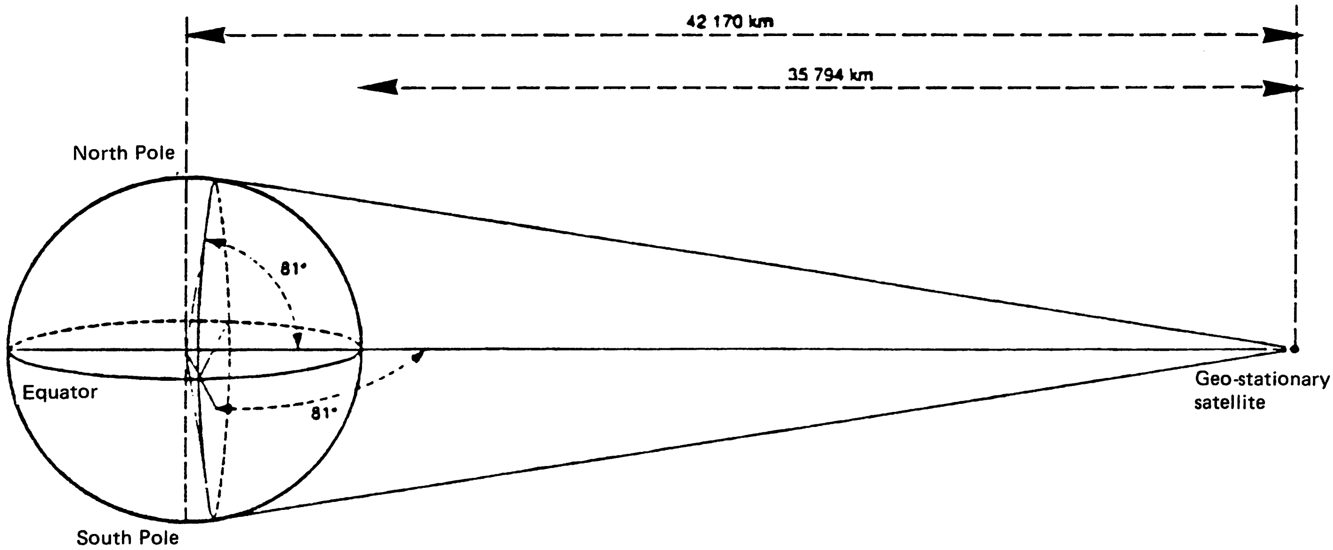
Geo-stationary orbit

When a satellite moves at the same speed relative to a point situated on the equator, it appears when looked at from the Earth to be fixed. It is placed on a geo-stationary orbit at 36,000 km from the Earth. According to NASA, during the next decade, 75 per cent of the applications satellites will be using this orbit.

Placing in geo-stationary orbit takes place in two phases. The satellite is first placed in transfer orbit, 200/36,000 km, elliptical in form, the apogee being at

FIGURE II

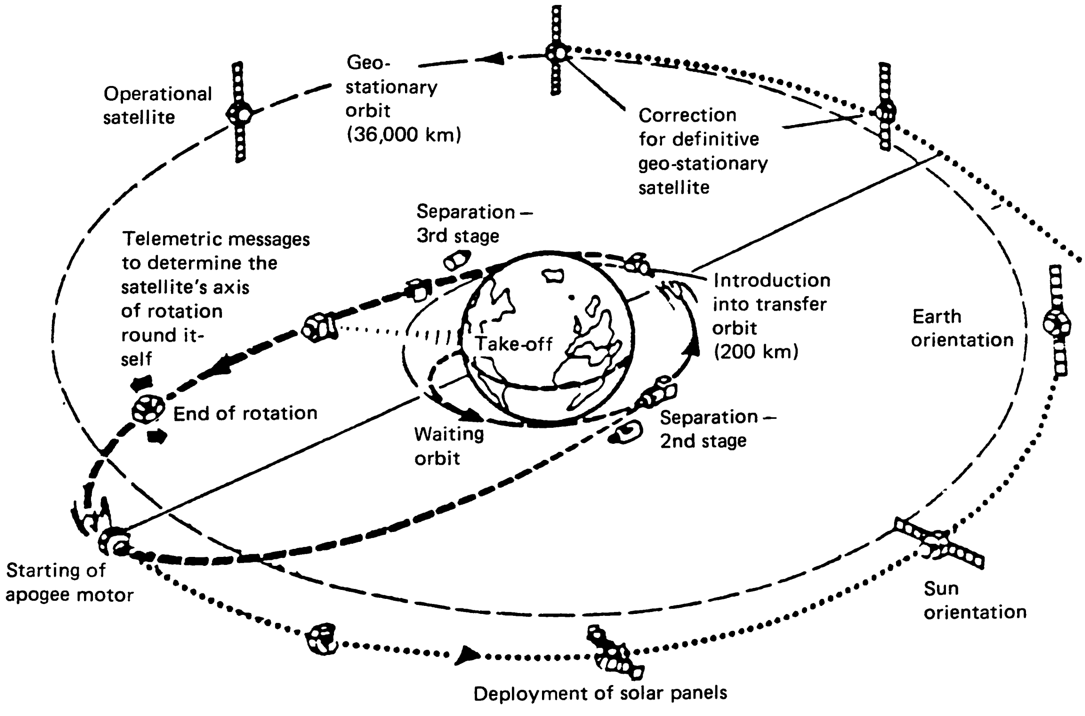
Spherical dome "illuminated" by the geo-stationary satellite



Source: Robert Genty, "Les possibilités d'emploi militaire de l'espace", *Stratégique*, No. 13, 1982.

FIGURE III

Techniques for placing in geo-stationary orbit



Source: "Les enjeux de l'espace", *Le Monde—Dossiers et Documents*, No. 119, February 1985.

the intersection with the geo-stationary orbit. When the apogee is reached, the satellite is then deviated from its course and propelled towards the geo-stationary orbit. This change of plane, resulting from the passage from a transfer trajectory to a circular orbit, is arduous in terms of the payload carried by the launching vessel, since the fuel needed for the manoeuvre has to be included in it. The further the launching base is from the equator, the greater the load of fuel that must be carried, which limits the payload accordingly.

The very high latitude of the USSR launching sites is thus particularly unfavourable for the installation of geo-stationary satellites. This is the reason why the Russians use a sub-geosynchronous orbit, which has been given the name of a class of satellites found there—the Molniya orbit.

TABLE 1

Latitude of some launching bases

United States	
Cape Canaveral	28.5°N
Vandenberg	34.6°N
USSR	
Baikonur-Tyuratam	45.9°N
Plesetsk	62.8°N
French Guyana	
Kourou	5.1°N
Japan	
Kagoshima	31.3°N
Tanegashima	30.5°N
China	
Shuang Cheng Tze	41.0°N

Source: J.-P. Penot, "La satellisation", *Défense*, No. 37, 1985.

Molniya Orbit

This is an elliptical orbit with a perigee of 440 km over the Southern Hemisphere and an apogee of 40,000 km over the Northern Hemisphere, enabling the USSR to make use of 80 per cent of the time taken by the satellite to make a complete revolution.

The choice between these various orbits depends on the missions for which the satellites were conceived. These missions are linked for the most part to military activities by the United States and the Soviet Union—the main space Powers. Thus, between 1957 and 1985, the USSR made 1,732 launchings, 59 per cent of them military in nature, while the United States made 796 launchings, 55 per cent of them military. The two Powers which carried out most satellite launchings following the USSR and the United States, namely China and France, are well behind, with 17 each, almost all of them, in the case of France, of a civil nature.[1]

This distinction between civil and military activities is, however, more and more difficult to establish for a number of missions.[2] This is the case with all matters relating to photographic reconnaissance. With Earth survey civil satellites, the American LANDSAT and particularly the French SPOT have in fact achieved a resolution figure, in the case of SPOT down to 10 metres (as against 40 metres for LANDSAT), enabling certain military installations to be observed, as is shown in the table below.

[1] By date of entry into the extremely select club, we find: USSR (Sputnik, 4 October 1957), the United States (Explorer I, 31 January 1958), France (Astérix, 26 November 1965), Japan (11 February 1970), China (1970), United Kingdom (1971), European Space Agency (1979), India (1980).

[2] In this connection see William Broad, "With Satellite Cameras, Civilians Join US-Soviet Spy", *Herald Tribune*, April 1986, and Peter Marsh, "Space ferret? Debate over intelligence control", *Financial Times*, 22 January 1985.

TABLE 2

Resolutions required for reconnaissance purposes

(Resolutions required (metres))

Objects	*Detection*	*Identification*	*Detailed identification*	*Description*
Bridges	6	5	2	1
Radar installations	3	1	0.3	0.15
Telecommunication relays	3	1	0.3	0.15
Troops (road encampment)	20	2	1	0.3
Aerodromes	6	5	2	0.3
Artillery batteries	1.5	0.5	0.3	0.2
Aircraft	5	1.5	1	0.2
Military posts	3	1.5	1	0.2
Tactical missile sites	3	1.5	0.5	0.3
Shipping	8	5	0.6	0.3
Vehicles	1.5	0.6	0.3	0.1
Minefields	10	6	1	0.1
Ports	30	15	6	3
Rail network	30	15	6	1.5
Built-up areas	50	30	3	3
Surfaced submarines	30	6	1.5	1

Source: Daniel Pichoud, *Air et cosmos*, 14 December 1985, based on a statement to the ENA colloquium, "L'espace, un défi pour la France", 28-29 November 1985.

According to French military circles, medium resolution-teledetection (between 10 and 30 metres) is "calculated to provide infrastructure information and to help in establishing data banks for designing numerical terrain models intended for new weapons (Cruise missiles)".[3] In the same context, while not directly linked with military matters but with extras involving problems of sovereignty, direct television satellites can become a source of international tension. For example, in July 1985, the Soviet agency Novosti likened diffusion without authorization to an act of piracy and described it as "ideological aggression". The Soviet agency stressed in this connection that every State has the right to take countermeasures to prevent such launchings, not only from its territory but also in space. Meanwhile, if we confine ourselves to the military activities as such of satellites, these can be divided into four categories.

Satellites for gathering information

Reconnaisance through photographs or images

Optical reconnaissance satellites transmit their pictures either via recoverable capsules ejected by the satellite at regular intervals, or again by radio transmission (KH 11). In 1986, the United States was due to begin to put into service a new type of optical reconnaissance satellite, the KH 12 (Ikon) which will be able to distinguish an object of less than one metre square 24 hours a day and transmit the data in real time, which will be particularly useful for the detection of mobile intercontinental ground missiles. The 1986 crisis of American launching systems (accidents involving the *Challenger* shuttle and the Titan and Delta rockets) retarded this launching. As far as the Soviet Union is concerned, its first photo reconnaissance satellite (Cosmos-4) was launched in 1962.[4] At present the Soviet Union is launching more than 30 satellites of this type a year. Their short life-span, less than two weeks, explains this rate of launching. It was not until 1982 that the Russians experimented with longer flights (of about 30 days). These satellites are beginning to have data transmission capacity. Their orbit is between 165 km (perigee) for very high-resolution satellites and 225 km (apogee) for those with a low resolution intended for zonal reconnaissance. At this altitude, they are vulnerable to direct attack by the American anti-satellite weapons system.

Electronic reconnaissance (SIGINT/ELINT/COMINT)

This is an area particularly shrouded in secrecy. We may recall in this respect the extreme secretiveness surrounding the mission of the *Discovery* shuttle, which in January 1985 put into orbit a satellite intended for electronic listening over the USSR from a geo-stationary orbit.

[3] Lt.-Col. Claude Ravalec, "L'imagerie spatiale—Dossier sur l'espace", *Armées d'aujourd'hui*, No. 98, March 1985.

[4] On Soviet military satellites, see Stephen M. Meyer, "Soviet Military Programs and the New High Ground", *Survival*, vol. 25, No. 5, September/October 1983.

The Russians have put into service two types of electronic reconnaissance satellites. Like the Americans, they have put into low circular orbit (600 km) a cluster of six ELINT satellites. They also have satellites intended for ocean reconnaissance which have been tested since 1967 and became operational in 1974. Following the incident with Cosmos-954, from which debris was scattered in Canada in 1978, and Cosmos-1042 (December 1982), the programme was interrupted. In August 1985 it started again, with the launching at a few days' interval of Cosmos-1670 and Cosmos-1677. This system comprises two families of satellites: EORSAT (ELINT Ocean Reconnaissance Satellite) equipped with passive listening systems, and RORSAT (Active Radar Ocean Reconnaissance Satellite). These operate in pairs at an altitude of 260 km in the case of RORSAT and 440 km for EORSAT, which has a distinctly longer life-span (180 days as against 90-120 days). According to the former Secretary of Defense, Harold Brown, the Russians would thus be able to inform their Backfire bombers equipped with Cruise missiles as to the American ships to be attacked. We know also, for example, that the sea-to-sea SSN-12 missiles can be used against very distant objectives (the missile's range is 550 km) on the basis of information transmitted to the vessel by an observation satellite. Like optical satellites, RORSAT and EORSAT are vulnerable to direct attack by anti-satellite weapons because of their low orbit.

Navigation satellites

These are satellites mostly placed in heliosynchronous orbit. The present navigation system for the American Navy (TRANSIT) is to be replaced by a system with far higher performance and for joint service use—the NAVSTAR Global Positioning System (GPS). Once this is operational, it will consist of 18 satellites (10 others will be ordered for replacement purposes) and will enable the user to plot the co-ordinates within 30 metres in the case of mobile installations and 10 metres for fixed installations. The NAVSTAR GPS also has a nuclear detection system (NDS—previously baptized IONDS: Integrated Operational Nuclear Detection System) which is able to detect and locate any nuclear explosion on a world-wide scale and transmit the information thus gleaned. This system is particularly important for American targeting and "intra-war deterrence".

On their side, the Russians have a system comparable to TRANSIT, namely NAVAST, comprising two clusters, one consisting of six satellites orbiting at 1,000 km on a series of separate levels, 30 degrees apart, the other cluster comprising four satellites orbiting at 45 degrees in relation to one another. Recently, the USSR has undertaken the exploitation of a new generation of navigational satellites called GLONASS, not unlike the American system NAVSTAR.

Communications satellites

In quantitative terms, communications satellites are the most numerous. They have also become more and more indispensable: 70-80 per cent of American long-distance military communications use this relay. Most of them are placed on geo-stationary orbit. Among the main communications satellite programmes, mention may be made of the following:

DSCS (Defense Satellite Communication System) the first version of which, DSCS I, operational since 1968, consisted of four active satellites and three placed in reserve. At the moment it is DSCS III which is in service. It consists of 14 satellites. It is more resistant to jamming and has twice the number of channels of its predecessors. It is the main high-capacity network used by the Department of Defense of the United States for its long-distance linkage. It is able to cope with communications of all kinds, incuding aircraft and shipping links between the American authorities (NCA-National Command Authorities). DSCS III is one of the segments of WWMCCS (World-Wide Military Command and Control System) set up in 1962 and at present consisting of 43 different systems of communication between NCA and the American forces.

AFSATCOM (Air Force Satellite Communication). This is a satellite communications network with airborne and ground terminals and UHF responders carried by various types of satellite. This system is due to be replaced at the end of the 1980s by MILSTAR. One of the important features of the AFSATCOM network is the SDS (Satellite Data System) network.

SDS consists of three satellites for data and speech links. It provides for transpolar links of special interest. The SDS satellites use the Molniya type of orbit.

FLEETSATCOM (Fleet Satellite Communication) became operational in 1980. It consists of four geostationary satellites located above the United States, between the Indian Ocean and the Atlantic Ocean, and over the Pacific. The system consists of 23 UHF channels (12 reserved for USAF, 10 for the United States Navy and one for NCA).

MILSTAR. This will consist of eight satellites making up an EHF telecommunications network very difficult to jam or to intercept. It will be toughened to resist the effects of electro-magnetic impulses. Terminals will be installed on the ground, but also on ships and aircraft (B-1B; B52; E-3A; E-3B).

On their side, the Russians have communications satellites, but their needs are less pressing than those of the United States, and hence the networks are fewer in number. They are made up of two tactical communication systems on an operations theatre scale (TACCOM), both of them revolving in low orbit. For strategic communication purposes, the Russians use Molniya satellites. Molniya I is made up of a galaxy of eight satellites, each with a life-span of approximately two years. Molniya II represented the Soviet contribution to direct linkage with Washington (Agreement of 30 September 1971 designed to modernize the "hot line" between Moscow and Washington) with two receiving stations, one at Vladimir in the USSR and the other at Fort Detrick in Maryland (the American component uses INTELSAT IV with two receiving stations, one at Etam in Virginia and the other in Moscow). Molniya II was abandoned in favour of Molniya III designed for civil communications. A series of receiving stations, both fixed and mobile (Orbita and Orbita-2) were installed, to correspond respectively to Molniya I and Molniya III. A mobile station was, for example, set up at Termez following the invasion of Afghanistan. For communications with their navy, the Russians have set up a Volna network with three satellites (one over the Atlantic, one over the Indian Ocean and one over the Pacific).

Side by side with these American and Soviet systems, mention may be made of the existence of British military networks (SKYNET), French (SYRACUSE, situated on Telecom 1A and Telecom 1B) and NATO. There are also many essentially civil communications systems (for example, INTELSAT).

Early warning detection satellites

Both the Russians and the Americans (Defense Support Programme—DSP) have put into orbit satellites for detecting intercontinental missile launchings. The American satellites are all in geo-synchronous orbit, and hence they are hardly vulnerable to ASAT attack, whereas the Soviet early warning satellites are in Molniya-type orbits.

2. Anti-satellite measures and their effectiveness

A satellite is merely a link in an overall system consisting of several elements deployed in space or based on the ground. Thus the ASAT weapon in a strict sense, namely launching a specific attack against a satellite, is only one of the possible ways of rendering the satellite inoperative or reducing its usefulness. In fact all the components of the system—the space segment, the ground segment and the links between space and Earth—are vulnerable to one or more types of attack.

Action against the space segment

It is possible to damage a satellite or to upset its functioning by attacking either the satellite itself or certain of its component parts.

Direct attack on the satellite

This can be carried out by projectiles aimed directly at the target, or projectiles with a military charge that projects shrapnel against the satellite. These methods are the basis of the ASAT devices which are operational at present or about to become so, and which are the subject of the section devoted to a comparison of the American and Soviet anti-satellite systems. Furthermore, "relativistic" weapons (lasers and particle bundles) are capable of damaging a satellite by thermal and mechanical effects or of impairing its electronic devices on board, according to the levels of power used. Again, the explosion of a nuclear charge close to the satellite could, through electro-magnetic impulses, wreck the electronic installations of its "victim".

Attack against certain parts of the satellite

Payload items. The optical instruments of the satellite could be put out of action, and its detectors completely destroyed, by laser weapons based on the ground. The telecommunication repeaters could be saturated or even destroyed by a ground station emitting a large amount of power on the right frequency band.

The power system. The solar generator in the satellite could be impaired or "polluted" by means of a ground-based laser.

The telemetry/remote control system. This is vulnerable to attacks similar to those directed against telecommunication repeaters.

Action against the ground segment

The importance of ground stations, set up to follow, remotely control or receive data gathered by the satellite, is vital. Destroying or putting out of action one or more of them could bring about an upset in the entire system and in doing so render one or more of the satellites inoperative. Similarly, damage to launching sites can help to reduce substantially the military capacity of the adversary in space by depriving him of the ways and means of putting into orbit new satellites designed to replace those destroyed by other anti-satellite methods.

Various types of action against the ground segment can be put into operation, from destruction by direct military attack (bombing of installations) to sabotage of the installations by terrorist or commando action.

Action against space-Earth links

Different methods can be used. The "spoofing" technique consists, for example, of using the satellite channels to send it false orders without the knowledge of the Power to which it belongs; to "fix" it in such a way as to make it impossible for it to carry out its mission subsequently; or to make it execute manoeuvres which can bring about its destruction. The advantage of this "soft" method is that the "signature tune" of the perpetrator of the deed is particularly difficult to identify.

It is likewise possible to attack the links between the ground and the satellite (jamming of the remote control links by transmitting on the same frequency from the ground under the reception cover of the satellite), or between the satellite and the ground (jamming the telemetry links or sending false information from a decoy satellite placed close to the target satellite and transmitting on the same frequency band). According to some sources, American aircraft carriers, for example, are equipped with electronic apparatus which can interfere with Soviet EORSAT/RORSAT systems. There is one other possibility of jamming, but it remains an exceptional measure, namely a very high altitude nuclear explosion (X-ray and gamma ray action and electromagnetic impulses).

Assessment of the military effectiveness of ASAT weapons

The effectiveness of a particular type of aggression depends on the time-lag between the decision and the moment when action is possible, its unobtrusiveness, the technical ease of putting it into operation, the effects caused to the aggressor's own satellites, and the vulnerability of the adversary to this type of attack.

It must be pointed out first of all that any object in space possessing the capacity to change orbit is a potential anti-satellite weapon, because of the relative speed of space objects. However, its capacity for use is reduced by the fact that the time-lag between the decision to attack and the attack itself can be extremely long, so that an attack against a satellite galaxy can involve a prohibitive length of time. Thus the time needed to put it into operation may serve as a criterion for the definition of an ASAT weapon. From this angle, an ASAT system launched from a launching platform, highly mobile over a great distance, is particularly important if the aim is either to strike a large number of targets simultaneously or to attack before the target satellite flies over a particular part of the earth. Actually, such a system makes it possible to go and place the launching point or points "under" the orbit of the satellite (or satellites in the case of the American system) without having to wait until the satellite in question passes "over" the line of fire of the ASAT weapon (in the case of the Soviet system).

Unobtrusiveness could rapidly become an essential criterion, bearing in mind the destabilizing nature of ASAT systems and the possible limitation of testing. This is all the more important in that an unobtrusive system can be tested, deployed and used when there is no confrontation. One of the characteristic features of such a system is its capacity to upset the performance of the satellite slowly or temporarily, without the satellite undergoing attack being "certain" that it is being attacked.

An example of this type of system might be laser weapons or radio transmitters based on the ground and particle bundles based in space. Several aggressive moves in the course of successive orbits, at a level of power far below a lethal dose, would after all damage the attitude and observation control sensors, the solar cells, the telecommunication or remote control receivers and the electronic equipment on board the satellite, which if attacked in this way would rapidly expire from this "galloping senility". It is obviously possible to place attack detectors on board satellites, but some doubt will probably persist as to whether there actually was an attack and as to the identity of the aggressor, at any rate in the case of radio transmitters, ground-based lasers or lasers carried on board ship. If such unobtrusive systems were put into operation, it can even be imagined their being used by the great Powers possessing ASAT systems in the event of localized conflict to help their regional "clients". Finally, such unobtrusive systems would involve heavy costs for the adversary to provide in peacetime for the replacement and toughening of its space vehicles.

Ease of operation, effectiveness, and effects achieved, are often bound together. It is obvious, for example, that any nation possessing nuclear technology and launching vehicles can explode a nuclear charge in space. The radiation thus caused is likely to destroy a considerable number of satellites, which will simplify the problems of trajectography of the target and guidance of the weapon. But in the same action, "friendly" satellites will be jammed, damaged and even destroyed.

Thus a system using an explosive charge which projects shrapnel against the satellite under attack will produce a cloud of projectiles which will remain for a long time in space and could damage other satellites. Similarly, a direct impact system that blows up the satellite under attack will also create debris which will tend to increase the level of pollution of space.

Finally, military efficiency also depends on the capacity of the adversary to replace damaged or lost satellites rapidly.

The Soviet approach to the military use of space makes their space systems intrinsically less vulnerable to ASAT attacks than those of the West. The Soviet Union each year launches about 100 satellites with a very short life-span as compared with that of the 10 or so satellites which the United States launches during the same period. This rapid Soviet launching capacity should enable the Soviet Union to replace destroyed satellites more rapidly.

Utilization of space for military purposes in a period of crisis thus presupposes on the part of the West the concept of launching vehicles usable at very short notice (today it is approximately three months) from more numerous and hence simpler and more widespread launching pads.

3. ASAT countermeasures

The countermeasures which can be envisaged to avoid anti-satellite aggression, to frustrate the activity of ASAT systems, and/or to minimize their consequences, are very diverse. It is likewise more than probable that they will evolve in time as the threats become more clearly focused and more diversified. It is, however, possible even today to divide them into two main categories, distinguishing between passive and active countermeasures.

Passive devices

Proliferation

One obvious countermeasure is to replace a sophisticated and costly satellite by a large number of simpler and hence distinctly less expensive satellites, so that an attack can only destroy part of the potential of the system.

Reduction of the detectability of satellites

At various times in the course of an attack, it is necessary for the command of the weapons system, and the interceptor, to locate the target exactly. This is done either by radar or by an infra-red detector. Any action enabling the "signature tune" of the satellite to be blurred will significantly complicate the problem which the attacker will have to solve.

Change in orbit

One of the vulnerable points of satellites is the high degree of predictability of their future whereabouts in space. This feature makes it possible to use very precise guidance systems working within a restricted volume. It is feasible to provide reserve satellites with fuel which will make it possible to modify, even slightly, the orbit of the satellite, either on a random basis from the point of view of the attacker (which can be called "passive means"), or when the satellite has detected the fact that it is being attacked. (In the latter case, the means might be described as "active".)

Diversity of the attitude control of sensors

Attacks against attitude control detectors attempt to blind the infra-red sensors by illuminating them with laser bundles, or by decoying the systems with the use of a radio frequency beacon emitting on the same frequency as the ground beacon used as reference. In order to combat this type of attack, it is desirable to reduce the field of visibility of the detectors and the reception diagram of the radio frequency beacon, so as to force the assailant to site his jamming apparatus at very precise and if possible controlled points. One can also imagine the coding of messages from the reference beacons, or using a laser bundle as reference.

Screening

Various forms of "armour-plating" can be used against attacks, whether by physical impact, nuclear means or radio frequency, provided that mass losses, which potentially may be considerable, can be tolerated.

Replacement of solar generators by nuclear sources

Solar generators are a particularly fragile feature. Because of their large size, it is possible to attack them with military charges which fire shrapnel, to illuminate them with high powered lasers so as to ruin the solar cells, etc. Moreover, because of their size and their method of utilization, solar generators act as excellent reflectors of the sunlight, which make them highly visible both to the naked eye and in the infra-red spectrum. The use of nuclear energy sources built into the body of the satellite is a possible solution to this problem.

Coding of telemetry and remote control links, and frequency modulation

To avoid both jamming and penetration of the satellite command system, it is essential to codify the information transmitted from or to the satellite, and possibly to transmit this information on frequencies which modulate rapidly in time.

Protection of ground stations

Ground stations, for telemetry, remote control or telecommunications, are by definition important points of access to the satellite. Their security must therefore be given priority attention.

Highly directional antennae or laser links

Highly directional antennae, and even more effectively, laser links, between satellites or between the satellite and the ground, reduce the volume within which the aggressor must operate if he wishes to intercept, jam or interfere in the transmission of information; this reduction helps to avoid aggression, or make it very difficult, and to identify the aggressor.

Long-life decoys

It is feasible to create bogus satellites having a "signature tune", as close as possible to that of the real satellite, within the frequency range used by the adversary's means of detection.

Active ways and means

Any active device necessitates detection of the attack made against the satellite or the system. This detection can be done from the ground (radar, optical observation network, surveillance of the links with the satellite) or from the satellite itself (a laser beam detector, an infrared detector, or possibly radar). The moment an attack has been detected and if possible identified, a number of types of action are possible:

"Shutting off the satellite" and silencing the radio

It is possible to block up the means of access to the satellite temporarily. In certain cases this will be detrimental to the mission, which will be interrupted temporarily—lost image or fouled input circuits of the telecommunication repeaters. There will be no short-term effect on the mission if the satellite has been properly designed—closing of the attitude-control sectors or stoppage of the telemetry/remote control linkages.

Short-life decoys

If the satellite is the subject of an attack by a missile endowed with a radar or optical self-guidance system whose method of functioning is fairly well known, it is possible to transmit short-life decoy signals having a signature tune similar to but stronger than that of the target satellite aimed at and taking the assailant missile with them calculated as they move away from the satellite.

Radar/lidar countermeasures

A satellite discovering that it is the subject of detection by radar or by a missile endowed with radar self-guidance can adopt countermeasures of the type used traditionally in fighter aircraft. It seems feasible for countermeasures of the same type to be taken against lidars.

Satellite defence systems

In the event of an attack by space mines (explosive satellites placed in the vicinity) or ASAT interceptor missiles, it is possible to imagine fitting the satellite with "anti-ASAT" missiles which would be fired so as to destroy the assailant before it could carry out its mission.

Antennae with directional gain modification

When the mission of a satellite calls for a relatively large emission or reception diagram, there is a danger that communications will be listened to or jammed by an assailant situated within the zone. In addition to obvious measures such as designing antennae having diagrams which vary rapidly within the coverage limit, it is possible to have "intelligent" antennae which, on detecting a jamming device, locate it in their reception diagram and modify the gain distribution in this diagram so as "not to listen to" the jamming. Similarly, in the case of an emitting antennae, it is possible to increase the power emitted in the desired direction, towards an operational zone, for example, thus interfering with the power output elsewhere.

Chapter II

COMPARATIVE STUDY OF THE AMERICAN AND SOVIET ASAT SYSTEMS

The increase in the number of satellites for military use, and the sophistication and diversity of the missions they are able to perform, as well as the fragility of their equipment, help to make them particularly vulnerable targets which it may be desirable to destroy in certain circumstances. Both the Americans and the Russians, realizing the military value of these space support systems, have for a long time been interested in the feasibility of anti-satellite weapons.

The first American ASAT systems,[1] the one using the Nike-Zeus anti-ballistic missile and the other the IRMB Thor, were developed as long ago as 1963 and remained operational for about 10 years. The Russians probably did not put ASAT programmes as such into operation before 1968, but ever since 1962 they appear to have been aware of the ASAT capacity of their ABM "Galosh" missile.[2]

Since then, Soviet-American competition in the ASAT domain,[3] and the debate on the strategic significance of these weapons, have gone on. Today, the United States and the USSR both have an ASAT system deployed or on the point of being deployed, their technical characteristics being very different and the respective efficacy being still difficult to evaluate.

1. Two different technical concepts

The two ASAT systems operational today, the Soviet "killer satellite" and the American PMALS (Prototype Miniature Air-Launched System) are based on two very different technical principles. The Soviet ASAT utilizes the co-orbital interception techniques, which causes the destruction or crippling of the target by another satellite which fires a charge of metal shrapnel at it. The American ASAT, on the other hand, using the direct ascension technique, enables the objective to be destroyed through the impact of an air-borne mini-missile.

These different technical options appear to reflect very dissimilar attitudes on the part of the USSR and the United States in regard to space technology. The Russians, as in the case of their other space activities, prefer to have recourse to a simple technique, well tried over a long period and hence able to be regarded as sure. They feel that the possession of a minimum anti-satellite operational capacity, even one based on a technique which may appear to be somewhat unsophisticated, is more viable politically and militarily than the search for brilliant novelty. With regard to the Americans, their mini-interceptor is a highly sophisticated achievement whose potential is great but the development of which is not proof against difficulties, linked first and foremost with the internal and strategic debate.[4]

The Soviet "killer satellite"

Before describing the Soviet co-orbital interception system, it must be pointed out that we have no documentation of Soviet origin that makes it possible to confirm with certainty the information at our disposal. Consequently, it is only possible to make conjectures as regards the real content of the Soviet ASAT programmes, and they can only be spoken of in the conditional.

The Soviet ASAT system as probably deployed today is the outcome of two series of tests carried out from 1968 to 1971 and from 1976 to 1982. In all, about 20 tests appear to have taken place (table 1, annex I). In the course of these tests, the interceptor satellites were invariably launched from the cosmodrome of Tyuratam in Kazakhstan, and the target satellites from the Plesetsk site in the north of European Russia.

An in-depth study of these two series of tests leads one to believe that in fact, three different ways of intercepting have been tested:[5]

Between 1968 and 1971 and between 1977 and 1981—Interception after at least two orbits, approach and radar pursuit of the target; rate of success 7/9.

Between 1976 and 1983—Interception from the first orbiting, radio guidance; rate of success 2/5.

Between 1976 and 1982 likewise—Interception at the end of two orbitings, guidance using an infra-red optical system; rate of success 0/6.

These results suggest that it is the first device—and also the oldest, since it was tested as long ago as the end of the 1960s—that was adopted.[6]

The interceptor vehicle, designated during the tests under the label "Kosmos", seems to have measured

[1] The very first American space inspection project (SAINT) was cancelled in 1962 without going beyond the research stage.

[2] For more information on the military component of the first Soviet space programmes, see Laurence Freedman, "The Soviet Union and Anti-Space Defense", *Survival*, No. 1, 1979.

[3] For more details on the ASAT weapons race, see Paul Stares, "US and Soviet Military Space Programs", in *Daedalus*, Spring 1985.

[4] A very full story of the American debate on the militarization of space will be found in the book by Paul Stares, *The Militarization of Space: U.S. Policy, 1945-1984*, Ithaca, New York, Cornell University Press, 1985.

[5] This classification, drawn up on the basis of several references, is given in the report of Aérospatiale, *Synthèse et analyse documentaire des systèmes d'armes anti-satellites*, Les Mureaux, 13 May 1985, pp. 127-129.

[6] See Stephen M. Meyer, "Soviet Military Programs and the New High Ground", *op. cit.*, and "Space and Soviet Military Planning", in William Durch, ed., *National Interests and Military Uses of Space*, Cambridge, Massachusetts, Ballinger, 1984.

about six metres and weighed between two and four tons. Launched by an F-1-m rocket (a modified version of the SS-9 missile), the killer satellite as a rule makes two orbitings before undertaking the interception manoeuvre. In order for this to be done, the orbits of the interceptor and the target must be virtually coplanar (in general they are almost touching, the orbit of the "killer" being slightly lower). In the terminal phase, the warhead of the interceptor, guided to the objective by an active radar beam, explodes, projecting a multitude of small metal pellets similar to buck-shot. This "bombardment" is apparently sufficient to destroy the vital electronic installations of the satellite under attack, the distance between the interceptor and the target would appear to be 1 to 9 kilometres. Figure I in annex I gives a schematic picture of the mechanism for interception by the Soviet killer satellite.

The American F-15/MHV interceptor

The American ASAT system is the outcome of studies begun in the early 1970s and speeded up from 1976 onwards (table 2, Annex I). The decision, taken by President Ford in response to the resumption of ASAT tests by the Russians, was confirmed by Jimmy Carter as part of a policy consisting of engaging in negotiations on ASAT arms control while pursuing research programmes. The anti-satellite weapon development programmes, maintained after the breaking-off of the ASAT discussions in 1979, received a great deal of attention from the Reagan Administration even before the launching of SDI.[7]

The present system entered the in-flight testing phase in 1984, and was tested successfully against a discarded Solrad satellite on 13 September 1985. It was to be deployed by 1987-1989, but it is to be feared that the one-year moratorium imposed by Congress at the end of last year on tests against real targets in space will involve some delay in this time-table. A shot aimed at a fixed point in space (in this instance, a star) was fired on 22 August last. The advocates of the American ASAT deduce positive conclusions from this in regard to the future of the system, while the debate on the desirability of repeal of the Congress decision continues.[8]

On the other hand, space interception by hunter satellite took place within the framework of the SDI programme on 5 September 1986. This experiment—the first interception of this kind carried out by the Americans—likewise testifies to the similarity between the anti-missile defence techniques and the anti-satellite systems.[9] The present version of the American ASAT system consists of three supplementary elements: a space projectile, an air-borne missile and an aircraft—the F-15 fighter plane.

The original feature of this system in that, unlike the Soviet ASAT weapon, the American interceptor is not placed in orbit, but is launched like an ordinary missile from an aircraft. Another specific point: interception is achieved in two stages. First of all, the F-15 plane, flying at approximately 18,000 metres altitude fires a stock missile 5.4 metres in length. This actually consists of a first stage embodying the motor of the SRAM tactical missile (Short-Range Attack Missile) and a second stage involving an Altair III motor. When the fuel is completely consumed, it ejects the space projectile. This mini-missile, 35 cm long and known as MHV (Miniature Homing Vehicle) is a sort of cylinder 30 cm in diameter. It is self-guided by an infra-red system, and it lashes the objective and destroys it by simple impact at a speed of approximately 13 km/s. Figure II in annex I illustrates the principle of interception by direct ascension used by the Americans.

The advantages of the American concept

A study of the technical characteristics and methods of functioning of the Soviet and American ASAT systems indicates the technological superiority of the latter, inasmuch as it embodies more sophisticated peak technologies and seems to be both more manageable and less vulnerable. Technically speaking, the American system has two great trump cards. In the first place, it demonstrates America's advancement in the field of miniaturization of components, as against the Soviet backwardness in micro-electronics and micro-engineering (the capacity to design and construct miniaturized systems). At the same time, it has been possible to equip it with infra-red sensors with cryogenic cooling systems, which add to its precision of aim and make it more unobtrusive in relation to the target, whereas the Soviet attempts to master this type of guidance system have been a failure.[10]

The American ASAT missile, compact and precise, is characterized by an operational flexibility superior to that of the Soviet killer satellite. It also seems less vulnerable to possible countermeasures. It is more mobile, since it is deployed on an aircraft, and it is also more unobtrusive because of its small size, its orthodox appearance (after all, how is one to know what F-15 plane is equipped with an ASAT missile?) and its infra-red guidance system, which is more difficult to detect than the active radar used by the Russians.

Furthermore, the theoretical possibility[11] of having F-15s take off from any point on the globe disposes of the problem of inaccessible orbital inclinations, unlike the Soviet ASAT, which is restricted by the geographical location of launching pads with inclinations higher than 45° (the inclination of the interceptors in the course of the testing was in general about 65°).

Speed is another plus for the American ASAT. Whereas it takes the Soviet interceptor 4-5 hours to reach orbit and to approach the target (without reckoning the time for preparing and launching the rocket), interception by the American MHV takes only about 10 minutes, which leaves the target very little time to identify the threat and if necessary to try to react. Figure III in annex I shows the comparative dimensions of the two interceptors.

[7] See Stares, *The Militarization of Space (op. cit.)*.

[8] See *New York Times*, 23 August 1986.

[9] For more detailed technical information on this test, see Albert Ducrocq, "SDI: les satellites défensifs" *Air et cosmos*, No. 1111, 4 October 1986.

[10] On the technological shortcomings of the USSR, see Stephen Meyer, "Soviet Strategic Programs and the SDI?", in *Survival*, November/December 1985.

[11] In practice, the F-15 ASAT missile carriers would be deployed at the Langley Base in Virginia and from McChord in Washington State.

2. Comparative military usefulness of the two systems

The sophistication of the American ASAT as compared with the crude nature of the Soviet interceptor does not mean that in terms of military usefulness, the former is "better" or "more effective" than the latter. The performance of an ASAT system depends largely on a series of factors other than mere technical superiority, and it is only through a combination of these various parameters that it is possible to evaluate the real threat represented today by one or other ASAT system. In short, it is not so much the weapon as such that represents a threat as the way in which people want to and are able to use it.

It should be noted that the conclusions reached can be challenged—the debate on the military use of ASAT systems being by no means decided definitively—and may be called into question in the fairly near future with the introduction of new interception techniques, the perfecting of countermeasures, and the evolution of theories on the use of ASAT weapons.

Efficacy limited to low-orbit use

From the point of view of the number of targets they would be likely to reach, both the American interceptor and the Soviet killer satellite today represent only a limited threat. Since the range of the American ASAT is estimated at about 500 km[12] and that of the Soviet ASAT at 1500 km,[13] they would seem to be dangerous only for satellites situated in low orbits. The following tables provide some interesting information concerning the number and nature of the satellites within range of the existing ASAT devices.[14]

TABLE 1

American satellites threatened by Soviet ASAT weapons

	1983	*1989*
Total number of satellites	94	141
Number of satellites threatened	29	24

Soviet satellites threatened by American ASAT weapons

	1983	*1989*
Total number of satellites	90	67
Where the maximum range is 500 km	26	10
Where the maximum range is 500-3000 km	80	26

[12] Since the interception altitude of the American PMALS has not been officially announced, the figures given differ according to the sources. The figure of 1,500 km announced by *Aviation Week and Space Technology* would seem to be excessive.

[13] Maximum interception altitude reached during a successful Soviet ASAT test carried out in June 1977. See Nicholas Johnson, *The Soviet Year in Space 1983,* Colorado Springs, Teledyne Brown Engineering, 1984.

[14] These tables were drawn up on the basis of data furnished by John Pike, "Anti-Satellite Weapons", *F.A.S. Public Interest Report,* November 1983.

TABLE 2

American and Soviet military satellites vulnerable to ASAT weapons

(By satellite category)

	United States	*USSR*
Photo-reconnaissance	4	2
Radar surveillance (RORSAT)	–	2
ELINT	12	10
Military communications	2[a]	33[b]
Navigation	5	10
Military weather forecasting	2	3
Early warning	–	9[c]
TOTAL	25	69

[a] The only American military communication satellites placed in a strongly elliptical orbit. The other satellites of this category (20) are in geo-stationary orbit.

[b] 29 in low orbit and 4 in Molniya orbit.

[c] All the Soviet early warning satellites are in Molniya orbit. Since the perigee is approximately 400 km from Earth, they are within the range of the American ASAT in its present version.

From an examination of these tables, the following conclusions may be drawn:

The fact that a larger number of Soviet military satellites in orbit are accessible to American ASAT weapons means that the United States could today inflict more damage on the adversary's vital space systems, even though the United States' range would appear to be shorter.

This situation could change in favour of the USSR. The Russians will certainly be in a position, within the next few years, to place a growing number of satellites of vital importance (communications, navigation, early warning) in geo-stationary orbit, thus putting them beyond the range of the American ASAT weapons.

ASAT performance and options for its use

To make a satisfactory evaluation of the military usefulness of each of the existing ASAT weapons, we would have to review all the scenarios of conflict where the use of ASAT weapons might be envisaged. The specific nature of the strategic philosophies of each of the States and of the structure of their military devices would in particular have to be taken into account. In the absence of a study of all the possible options, however, it is possible to stress certain points which illustrate the impossibility of deciding once and for all in favour of the one or the other ASAT system.[15]

The threat underlying an ASAT system is determined by the strength of the supporting space systems as part of the military equipment of each of the protagonists. The usefulness of a weapon is to a large extent determined by the usefulness of the target. The State whose degree of dependence on its military satellites is greatest will be the one most exposed to an ASAT attack and the one most affected thereby. Indeed, the benefit of an at-

[15] For a more detailed analysis of scenarios and options for the use of ASAT weapons, see Stephen Meyer, "Anti-Satellite Weapons and Arms Control: Incentives and Disincentives from the Soviet and American Perspectives", in *International Journal,* Summer 1981.

tack on or of more or less severe damage to enemy satellites is not the same for the United States as for the USSR, not even in the light of the type of satellites concerned. As far as one can see, there seems to be an imbalance in dependence unfavourable to the United States, particularly in the sphere of reconnaissance and communications by satellite. Reconnaissance satellites represent for the Americans a prime means of gathering information on the Soviet military forces, whereas the USSR uses more traditional spying techniques more easily.

In the same way, America's dependence on communications satellites is also greater. This is due to different reasons, not the least important of which has to do with the size of the continental land mass of the USSR and hence with the location of theatres of operation within the immediate periphery of Soviet territory. In the event of a conflict in Europe or in Asia, the USSR could easily use land communication lines, whereas for the United States, communication by satellite with their overseas forces is much more vital. Stretching their military lines obliges the Americans to make priority use of the satellite communication network in communicating with forces situated thousands of miles away from the national territory. But it should be stressed that America's means of reconnaissance and communication are more than enough, and that dependence on space is not absolute. For example, mention may be made of the NSA listening centres, the daily ELINT operations of the United States Air Force, and for the Navy, various listening programmes (Sosus network, Holystone programme, etc.).[16]

With regard to the USSR, we find a certain imbalance between the strategic usefulness of the Soviet ASAT system, potentially important in the event of a nuclear conflict, and the technical limits of the system. This contradiction may be illustrated by the example of the early warning satellites. In the event of a nuclear exchange between the two great Powers being launched by the Soviet Union, the USSR would be well advised first of all to eliminate the American early warning satellites so as to accentuate the element of surprise, to create confusion, and to reduce the American second strike capacity. This was in fact apparently the logic behind the ASAT test carried out by the USSR in June 1982, as well as the ICBM, SLBM and SS-20 tactical weapon firing tests. Conversely, the Americans would have little to gain from the destruction of Soviet early warning satellites, first of all because these do not have a very high performance, and secondly because they would be of very little use to the USSR in the event of the USSR making the first strike. However, this statement must be qualified by the fact that for the moment it is the American ASAT which would be able to destroy the USSR's early warning satellites (at the perigee of their Moniya orbits, 400 km from the earth), since the Soviet ASAT weapons cannot reach the geo-stationary orbits where the American satellites of this type are to be found.

The effectiveness of ASAT weapons varies also according to the nature, the duration and the intensity of the conflict. In view of the role of satellites in the development of the traditional type of conflict (C3 networks, surveillance of troop movements, ocean reconnaissance, meteorological work, etc.), the incidence of ASAT in the context of a conventional war would be important. The superior operational quality of the American ASAT system leads one to think that it would be capable here and now of causing considerable damage among the Soviet satellites. It would be particularly useful against the Soviet RORSAT radar ocean reconnaissance satellites.[17] At the same time, the Soviet Union appears to have greater capacity to replace lost satellites. The Russians are in the habit of launching more satellites than the Americans, and their launching technique would appear today to be more effective (100 launchings a year for the past 10 years or so).

Outlook: a race without a "winner"?

Since they start out from two different approaches to the problem, the Soviet Union being motivated by the desire to improve its overall military capacity by possessing a supplementary weapons system, and the United States being anxious to respond to this Soviet initiative by reformulating its own ASAT weaponry, the two Powers have finally reached comparable levels of ASAT development. Even though the Soviet Union has ceased testing its interceptor satellite (because of the moratorium of August 1983), and in spite of some delays with the American project, about 15 Soviet ASAT weapons could be deployed between now and 1990, whereas it is estimated that the American ASAT weapons should reach full operational capacity towards 1989.

It is not possible today to point to a "winner" in the American-Soviet competition in the ASAT field. There are considerable differences in technical design between the two systems, the American system being more manageable, more unobtrusive and faster. This appears to be in its favour in relation to the Soviet interceptor, which is cumbersome and slow. However, the superiority of the American ASAT is not absolute. Since the performance of an ASAT weapon is measured also in terms of its military usefulness, the Soviet system, although technologically inferior, could in certain circumstances have greater strategic significance. Tomorrow's "winner" will be the Power which has at once a technically more sophisticated ASAT weapon and a very coherent doctrine of using ASAT in the framework of the overall strategic situation.

Finally, it must be pointed out that the present situation is quite likely to evolve in the relatively near future. First of all, the number of Soviet satellites in geo-stationary orbit and invulnerable to ASAT weapons will certainly increase. Secondly, the scope of the killer satellites can be extended to the use of launching vehicles of greater power which the Soviets are in the process of setting up.[18] Finally, the development of ASAT weapons with directed energy (laser, particle

[16] Desmond Ball, "Nuclear War at Sea", *International Security*, vol. 10, No. 3, Winter 1985-1986.

[17] On the role of ASAT weapons in classic-type conflicts, see Eric Raiter, "Les armes anti-satellites", *La Recherche*, December 1985.

[18] It is thought that on 30 July 1986, the USSR carried out a test of its new SL-16 launch vehicle with a cryogenic propellant (Kosmos 1767).

bundles, etc.) undertaken by the two Powers is likely to turn the data of the problem topsy-turvy.[19]

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The ASAT race just described constitutes henceforth an undoubted threat to the safety of space systems and could in particular jeopardize the development of the peaceful uses of space by third countries. Is there still time to stop this process? Is it still possible today to contribute to the reduction, if not the complete disappearance, of the anti-satellite peril?

Chapter III below analyses the gaps in the present legal system governing space. The conclusions reached suggest that in order to remove the ASAT danger, the existing legal norms would have to be supplemented by other measures, concerning in particular the behaviour of States in the conduct of their space activities.

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[19] On the possible evolution of the ASAT problem, see Ashton Carter, "Satellites and Anti-Satellites: the Limits of the Possible", in *International Security,* Spring 1986, and the Report of the Office of Technology Assessments, *ASAT, Countermeasures and Arms Control*, 1985.

Chapter III

ASAT WEAPONS AND INTERNATIONAL LAW

It must be pointed out immediately that positive law is both deficient and poorly-adapted to the present outlook on the development of ASAT weapons, which as such are only exceptionally covered by precise rules. This is due partly to the fact that ASAT technology is recent and not properly embraced by the foresight of those who drew up the existing rules, and partly to the extreme diversity and complexity of ASAT weapons, which makes it extremely difficult, if not impossible, to pin them down under hard and fast rules. To isolate and define "ASAT" in legal terms, apart from vague principles hard to put into practice, is something of a gamble.

We propose first to give a definition of ASAT weapons, then to recall the general characteristics of the law applicable to them, and thirdly to deal with the problem of their future regulation under law.

1. Definition of ASAT weapons

From the legal point of view, ASAT weapons are ways and means that can be used, with malicious intent, for the purpose of damaging, destroying, or seizing a satellite, or making it unusable by its owner. The object of this definition is to embrace as completely as possible the various devices capable of carrying out a deliberate attack on the satellites of other parties. It does not necessarily fit a specific type of regulation. Before it can be and remain operative, an effective definition must avoid two pitfalls: being too abstract and general, or being too precise and descriptive (enumeration of types of objects, for example, which would very quickly make it obsolete).

An important distinction should be made first of all between ASAT weapons *by nature* and ASAT weapons *by destination*. The former are built and prepared for use essentially to attack and put out of action the satellites of other parties. The second consist of other weapons, such as nuclear weapons or anti-ballistic weapons, which can be used against satellites, or can have secondary effects in relation to them. They also include techniques ordinarily intended for peaceful uses but incorporating a virtual military purpose.

In the case of ASAT devices which are first and foremost weapons, with a military purpose, a distinction should be made, according to the specific regulations governing them, between nuclear weapons and other weapons of mass destruction, and anti-ballistic weapons. This blanket definition covers the whole of an ASAT system, whether it is set up for this purpose alone, or can be assembled at a given moment from a variety of miscellaneous elements, for hostile purposes (launching devices, vehicles, apparatus for causing damage, capturing or destroying, etc.). It does not prejudge distinctions which might prove necessary in the search for legal regulation.

2. General features of the law applicable

This law is by no means homogeneous and rigorous. Both in its formal features and in its content, it would appear to be inherently fragmentary and composite. Let us look at five characteristics of this law, one after another: it is essentially convention-oriented; it is piecemeal; it is a law of general principles, but also a contingent law; and finally, it tends to create or crystallize situations of inequality.

An essentially convention-oriented law

Among the main instruments that can be mentioned which, as a rule implicitly, concern ASAT weapons, we have first of all treaties, the object and membership of which are fairly large:

The Charter of the United Nations—its provisions relating to the use of force, and indeed to the peaceful settlement of disputes;

The Moscow partial test-ban Treaty (1963, multilateral): Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water;

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967, multilateral);

The Anti-Ballistic Missile Treaty (1972, bilateral, between the USSR and the USA), concluded in the framework of the SALT negotiations;

The 1971 and 1973 Agreements on Measures to Reduce the Risk of Outbreak of Nuclear War, on the Prevention of Nuclear War, and on the Strengthening of Bilateral Means of Communication (bilateral, between the USSR and the United States of America);

The Convention on Registration of Objects launched into Outer Space (1975, multilateral);

The Environmental Modification Convention (1977, multilateral);

The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (multilateral);

The SALT II Agreement 1979.

Other treaties could also affect ASAT problems, for example:

The International Telecommunication Convention (1982, multilateral);

The Convention on International Liability for Damage caused by Space Objects (1972, multilateral).

Multilateral agreements concerning outer space

	Date of signature	Number of parties
Charter of the United Nations	1945	158[a]
Antarctic Treaty	1959	32[b]
Partial Test Ban Treaty (banning nuclear weapons tests)	1963	111[b]
Treaty on Outer Space	1967	92[b]
Treaty of Tlatelolco	1967	29[b]
Non-Proliferation Treaty	1968	127[b]
Seabed Treaty	1971	81[b]
Convention on International Liability for Damage Caused by Space Objects	1972	72[a]
Biological Weapons Convention	1972	104[b]
Convention on Registration of Objects Launched into Outer Space	1975	32[b]
Environmental Modification Convention	1977	54[b]
Moon Treaty	1979	4[a]
International Telecommunication Convention	A. 1973	156[a]
	B. 1982	8[c]

Sources: M. J. Bowman and D. J. Harris, *Multilateral Treaties: Index and Current Status*, London, 1984; United States, Arms Control and Disarmament Agency, *1984 Annual Report*, Washington, April 1984.

[a] As of 31 March 1984.
[b] As of 31 December 1984.
[c] As of 30 June 1985.

However, the predominance of the convention régime here does not mean that other norms may not be appropriate. These can first of all be written norms as formulated in resolutions, particularly those of the General Assembly of the United Nations. But apart from the fact that in themselves they are not binding in character, such resolutions generally form part of a conventional process, constituting bases or stages in the implementation of multilateral conventions, or calling for negotiation of such conventions.

There is also custom, which although relegated to the background by the preponderance of treaties in this context, is not entirely absent from the legal régime of space. This is true, for example, inasmuch as in general, international law as a whole applies in space, and is in part customary (article III of the 1967 Treaty); more particularly because certain conventional rules that are applicable have been confirmed and extended by customary means. Hence they have acquired the status of customary rules, extending beyond the circle of the States parties. This would appear to be the case with the principles of the 1967 Treaty. Finally, it may be mentioned that the legal status of the SALT II Agreement is uncertain, particularly following the decision by the United States not to observe its provisions any longer.

Thus, this essentially convention-oriented basis has the advantage of binding the parties to the Treaties, of being mandatory for them, and of thus providing an unassailable foundation for the rules applicable. Nevertheless, from the point of view of the authority of the norms, it has serious practical limits. Among these, mention should be made first and foremost of the vagueness of the principles proclaimed, and their ambiguity in regard to ASAT weapons. For example, what is the meaning, from this point of view, of the first paragraph of article IV of the 1967 Treaty, which reads:

> 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 weapons in outer space in any other manner.

It may be thought that this provision does not concern ASAT weapons, which do not belong, at any rate, primarily, to the categories of weapons and activities expressly referred to. But in the general philosophy of the Treaty, does not the systematic development of ASAT weapons tend to rob it of its purpose and its aim?

Furthermore, many of these conventional instruments are shaky and can be easily and rapidly denounced. This is the case of the Soviet-American SALT Agreements, which are bound up with a situation of balance and a climate of confidence which conditions their effectiveness, and in theory with the success of further negotiations. The same is true of the permanent-type treaties such as the 1967 Treaty, which under the terms of article XVI can be denounced by simple withdrawal subject to a year's notice being given (the period of notice is three months in the case of the Moscow Treaty of 1963, article IV, and six months for the 1972 ABM Treaty, article 15, para. 2).

What is more, even confining ourselves to the conventions which represent the hard core of the legal régime, these do not constitute a co-ordinated whole, but appear rather as a miscellaneous series of partial instruments.

A piecemeal law

Its piecemeal, fragmented nature can be appreciated on two levels, that of the norms and that of the parties. The development of space law, even confined to the problems of peace and security, does not follow an unbroken logic such as might, for example, be based on a combination of general rules and particular rules, the latter applying and clarifiying the former. This is not precisely the case, and hence it is not possible to regard the SALT Agreements, or the 1973 Treaty on the Prevention of Nuclear War, as measures for the implementation of the 1967 Treaty. Actually, they obey two different types of logic: the general prevention of the arms race in space in the case of the latter treaty; the establishment of a common approach, or at least a concerted and bilateral approach, to the strategy of dissuasion in the case of the former.

Nor can it be considered that there is adaptation of an unbroken logic in the succession of the negotiations and of the treaties. We can certainly agree that they converge on the same goal of stabilizing dissuasion. But the legal procedures lack real co-ordination. No constant effort has been made, for example, to define the types of arms or threats that can be envisaged. These are referred to, sometimes vaguely—for example, in the 1967 Treaty, weapons of mass destruction, which covers certain ASAT weapons, but not all, and not the core of them—and sometimes very precisely, as in the SALT Agreements, with a comprehensive definition of ABM in article 2, but one exclusively concerned with anti-missile systems, and not with ASAT weapons.

Finally, it may be recalled that all restrictive or prohibitive instruments are saddled with an implicit but inescapable reservation, namely that of self-defence. This is written into the Charter, which in virtue of its own provisions supersedes all the obligations assumed by States. Self-defence, moreover, far from being an exception to the prohibition of resort to force, is rather a consequence of it, and it can be regarded as incorporated in the very rule which forbids resort to force in any manner incompatible with the principles of the United Nations, Article 2 (4). What this means is that all measures prohibiting certain weapons, or certain uses of weapons, or certain forms of development (testing, deployment, etc.) are in the nature of exceptions to the possible use of weapons in self-defence. Concretely, this virtuality affects even the notion of exclusive use for peaceful purposes as formulated, for example, in regard to the Moon and celestial bodies, in article IV, paragraph 2 of the 1967 Treaty. This does not take precedence over the exercise of self-defence, even though the permanent installation of bases, testing, or manœuvres, manifestly going beyond its framework, are still prohibited.

There is fragmentation also in regard to the parties, since the pertinent treaties are very uneven in their ratification. It is only partly justifiable to set multilateral treaties of the 1967 Treaty type in principle against bilateral treaties of the SALT type. Actually, there is a whole range of intermediate situations, with multilateral treaties which few countries have ratified (for example, the Moon Treaty of 1979, the Convention on Registration of Objects Launched into Outer Space, 1975, the Environmental Modification Convention, 1977), or in which a significant number of countries have failed to participate (e.g. the Moscow Treaty Banning Nuclear Weapons Tests, 1963, or the NPT of 1986), whereas important bilateral agreements involve third parties, even though legally unable to affect them without their consent (for example, the 1973 Agreement on the Prevention of Nuclear War).

Thus, far from making for a homogenous régime, uniformly applicable to the international community, the treaties in force form a network of somewhat craven, half-hearted and incomplete obligations. These characteristics, by and large negative, reappear if we look at the content of the treaties.

A law of general principles

In spite of its *ad hoc* nature, the law on the military uses of space frequently has recourse to an abstract and general terminology, e.g. articles III and IV of the 1967 Treaty, and also articles VII to XI, relating to liability, jurisdiction and co-operation in the field of the exploration and utlization of space. While these principles only implicitly cover ASAT weapons, they are nevertheless sufficiently precise in their contents to make it possible to draw certain conclusions in respect of them.

Thus a distinction is established between space proper and the Moon and celestial bodies: in the latter instance, they can be used "exclusively for peaceful purposes". The former, on the other hand, is in no sense demilitarized, and the prohibitions laid down are restrictive: on the face of it, the placing in orbit or launching into space of ASAT weapons, which are neither nuclear weapons nor weapons of mass destruction, is not prohibited, and their use remains subject to the general provisions of the Charter "in the interest of maintaining international peace and security" (Article III). Questionable activities are to be the subject of "appropriate" consultations. But no precise verification procedure is provided for, and the opportunity for observation of "the flight of space objects ... shall be determined by agreement between the States concerned" (article X). On the other hand, according to article XII, "stations, installations, equipment and space vehicles on the Moon and other celestial bodies shall be open to representatives of other States on a basis of reciprocity".

This verification by national means therefore concerns ASAT weapons. It is nevertheless clear that these general provisions operate only very half-heartedly in respect of ASAT weapons. They envisage them not as such but, by implication, as space objects, or as constitutive elements of such objects. It does not seem likely that except from the point of view of liability, they can cover the use of ASAT weapons from the Earth, any more than their operation from the Moon. Only "the establishment of military bases, installations, fortifications", and "the testing of any type of weapons" are prohibited. But, for example, would the physical use of the Moon as a relay post for an ASAT system be at variance with "peaceful purposes", since its utilization would be purely defensive? This question reveals the limits of an abstract and general approach. These limits are largely explained, paradoxically, by the consideration that in actual fact the law governing the military uses of space is still a contingent law.

A contingent law

This is true of most instruments, whatever they may be in appearance. They are designed to respond to a concrete situation—for example to avoid aggravating an arms race which no side is certain of winning. But the commitments are limited to the immediate or proximate outlook, and they cannot be projected into a technologically unforeseeable future, which everyone would anyway prefer to leave open. Hence the outlook remains essentially subject to a régime of free enterprise.

This is the case with the 1963 Treaty, which does not prohibit underground nuclear tests; the 1967 Treaty, which is mainly concerned with demilitarizing the Moon and prohibiting the satellization of nuclear weapons; the SALT Agreements, which are the most obviously contingent, even though they are planned as part of a continuing process of bilateral negotiations, since they deal in a precise way with systems of weapons which exist or can be envisaged over the short term. With regard to the latter series of treaties, the 1972 ABM Treaty contains a provision (article XII, para. 2) which implicitly and indirectly covers ASAT when it states that "Each Party undertakes not to interfere with the national, technical means of verification of the other Party", thus providing in principle a safeguard for control satellites, but on the basis of reciprocity and only in a bilateral framework—in other words, inequality is a basic characteristic of this law.

A law that makes for inequality

Inequality between States, whether or not they are parties to the whole or only to some of the instruments in the matter, is ever present. It is not merely the outcome of the differentiated network of obligations accepted by States; it is probably at the root of their commitments or their initiatives. Their concern is to protect acquired rights, to preserve the benefit of advantages gained, to avoid being overtaken or outstripped. This inequality is not in any way at variance with balance; on the contrary, the notions are entirely compatible, and may even naturally be conditional one upon the other.

We shall not make an issue of inequality between nuclear Powers, as laid down and perpetuated, for example, by the Non-Proliferation Treaty (NPT). With regard to ASAT weapons, inequality would appear to be hardly pertinent, at any rate for the moment. All States would seem, however, to have an obvious interest in establishing a general régime of protection for satellites, wheatever the legal base may be. Inequality between nuclear Powers is likewise obvious, first as between the United States/USSR and the rest, and secondly, between the two champions of dissuasion, particularly in connection with ASAT as a sub-product of SDI. It is possible to cite a few examples of discrimination between nuclear Powers arising from the special understanding between the United States and the USSR, particularly within the framework of the SALT Treaty Agreements and kindred negotiations.

The same is true of the protection of national means of control mutually recognized by the two parties to the ABM Treaty of 1972, a type of protection not extended to third parties, whose satellites are not granted an explicit guarantee, even formulated in general terms, of free observation, without interference, in regard to opposing military and strategic devices. It is partly to cope with this inequality that France has been anxious to see an International Satellite Agency set up which might enjoy a similar guarantee and be able to make its observations known to all States. The same is likewise true of the limited, bilateral nature of the consultations which the two super-Powers undertake to hold in the event of a nuclear threat, even one implicating a third party, in accordance with the agreement of 22 June 1973. The effect of this agreement is virtually to place under surveillance, and in a non-reciprocal manner, the forces of dissuasion of the other nuclear Powers, and to set up the two States as a sort of nuclear Super Security Council. It will be remembered that it was as a result of this agreement that the expression "condominium" was used by Mr. Jobert, the French Minister for Foreign Affairs. The same is finally true of the Soviet wish to include the French and British nuclear forces in bilateral negotiations with the United States—which would amount to confirming and extending the overview right which the two super-Powers implicitly grant each other in relation to the others.

These prospects have, however, become less pressing because of the many difficulties in bilateral negotiations between the Americans and the Russians over the last few years, both because of the general political context and because of the launching of the SDI project by President Reagan in 1983. This project aims over the long term simply to bypass the dissuasion strategy by making nuclear weapons useless. Following a phase of research, it would go on to a stage of anti-ballistic defence leading to invulnerability. The USSR, fearing to find itself in an objective situation of inferiority, refuses absolutely to accept the American initiative. Hence the various diplomatic points and counterpoints, and in particular a draft resolution submitted at the thirty-ninth session of the General Assembly on 20 September 1984, aimed at the global prohibition and total liquidation of all space weapons. Hence again prospective measures on a military level designed to restore the balance.

3. The problems of legal regulation of ASAT weapons

Without pretending to pre-judge the content of the concrete measures for regulating ASAT weapons proposed in chapter IV of the present report, the following observations are designed to establish a number of distinctions, useful because of their legal approach, on the basis of the definition proposed above.

Distinction between activities relating to ASAT weapons

These activities can be envisaged in several stages:

Research. Research would seem to be extremely difficult to prevent, if only because of the difficulty of verification, let alone because of the highly changeable and unforeseeable nature of the scientific and technological procedures which can make it possible to attack satellites.

Testing. This no doubt constitutes the starting-point for bringing ASAT weapons within the law, inasmuch as testing can be prohibited, and compliance can be verified. But prohibition can presumably only be applied to full-scale experiments *in situ*, and not to laboratory experiments.

Deployment. Once the components of an ASAT weapon can be identified, their siting can be totally or partially (the directly aggressive part) forbidden. However, it is not certain whether distinctions should not be established on the basis of the location of these components. Prohibition is more difficult to impose on State territory (including home waters and the superjacent air space) than in international space (the high seas, the sea-bed, the superjacent air space, and outer space).

The permanent obstacle that subsists is that of *virtual* ASAT weapons, namely systems or objects which have a basically peaceful function but are able to be converted into military devices, so that the distinction between military and civil, and indeed between peaceful and aggressive, is hardly pertinent in this context.

Utilization. This is in principle forbidden, in so far as it relates to aggressive behaviour prohibited by general international law. A specific type of prohibition would strengthen this general prohibition, making it more precise, but it would not alter its nature. Moreover, utilization is still authorized in the context of self-defence. In the face of this difficulty, it might be possible to opt for an approach concerned not with

ASAT weapons, but with the virtual targets, the satellites threatened, reaffirming and strengthening their protection, for example by having recourse to the concept of "immunity", as suggested by France.

The implications of this notion, however, raise problems. Would there, for example, be increased liability in the event of an accidental attack on the satellites in question? A presumption of aggression? Would these satellites be under the shelter of self-defence measures? If so, should they not then demonstrate their exclusively peaceful character, and their inoffensive nature, as a basis of this immunity? We shall have occasion to revert to these various points in chapter IV below.

Distinction between the stabilizing and the destabilizing role of ASAT weapons

Without being expressly formulated in legal terms, such a distinction is implicit in the whole of the right to peace and security. Thus it is one of the bases of the foundations of self-defence. It is more particularly evident in the norms involving dissuasion, and it constitutes the basis of most of the prohibitive provisions of the treaties on control. It also explains the limitations of these prohibitions. Thus in the 1967 Treaty, whereas placing weapons of mass destruction in space is forbidden, transit is authorized as a factor in dissuasion. In the case of ASAT weapons, this distinction explains the different treatment for ASAT weapons in low orbit and in high orbit in the French memorandum dated 12 June 1984. It also explains the importance attached by the memorandum to the verification of undertakings given.

Problems of verification

The existence of effective verification procedures constitutes a guarantee of respect for undertakings given in this matter, as calculated to create a climate of confidence likely to prevent intensification of research and resumption of the arms race. The absence of these procedures in most treaties relating to *arms control*, and the doubts which have thus arisen as to the will to observe them, and as to their effective observance, is undoubtedly one of the main reaons for challenging them. Hence, if we wish to envisage an effective system for regulating ASAT weapons, it may not be sufficient, but it is certainly indispensable to begin with measures—norms of behaviour or bans on action—which can be controlled.

Among the ways of exercising such control, the formula of control by national means laid down in the ABM Treaty would seem to be imperfect. On the one hand, the exercise of control may at times be interpreted as bordering on unfriendly conduct; on the other hand, the States concerned are placed in a situation of inequality, since they do not all have appropriate means. A formula for international control might be more effective provided it introduced appropriate international procedures, and they were exercised in circumstances which do not interfere with the exclusive right of the owner of satellites to use them.

All in all, then, the international legal system, of itself alone, is far from making for a set of comprehensive "regulations", at once effective and verifiable, governing ASAT activities. Hence chapter IV, which follows, contains recommendations which, as we shall see, go beyond the mere domain of legal norms and are inspired rather by considerations of a political and strategic nature.

Chapter IV

RECOMMENDATIONS

The preceding chapters have revealed a lack of balance between the benefits deriving from the intensive exploitation of satellites and certain inadequacies in the regulations applicable to space activities today. In particular, the inability of States to guarantee the safety of space systems against the various anti-satellite devices must be seen as one of the major weaknesses of the present régime.

As we have seen, international law on outer space does not establish precise rules concerned specifically with anti-satellite weapons. Indeed, there are neither adequately suited legal norms, nor a control system aimed at limiting ASAT systems. In these circumstances, the definition of a new international régime to facilitate the slowing down of progress with existing ASAT systems and to prevent technological escalation in this field, becomes indispensable. While operational or developing ASAT systems (the Soviet co-orbital interceptor and the direct-ascent American missile) are only dangerous for targets in low orbit, it is more than probable that the production of systems with better performance, capable of reaching space objects in geostationary orbit, will be feasible in the years to come. All satellites would thus be vulnerable to the ASAT threat.

The establishment of a régime prohibiting all ASAT weapons, however, comes up against two series of obstacles due to the technical and political complexity of the problem. The first is the difficulty of defining an ASAT weapon itself. As the preceding chapters have shown, there is no single ASAT "weapon" as such, but a number of types of anti-satellite action, based on a wide variety of technical concepts. While all of them have the same purpose (in principle, to destroy or put out of action the military satellites of the adversary), ASAT systems can take highly diverse forms: space mines, interceptor satellites, direct impact missiles, laser weapons or particle beam weapons, electronic devices for jamming or interrupting communications, etc. Furthermore, space systems are equally vulnerable to attacks directed against the ground bases. They can be rendered inoperative by the destruction of ground-based control and relay stations. Also, other weapon systems (ballistic missiles with a nuclear charge, ABM interceptors, etc.) could have an operative ASAT capacity and could be fired from the ground against targets in space. Such a variety of ASAT measures makes it impossible in practice to formulate a single, exhaustive system of weapons for the purpose of banning them. There is also the key problem of verification. Most ASAT systems do not carry a "signature tune" ensuring their reliable identification either in space or on land.

There are political difficulties arising from the need to reconcile the divergent interests of the Powers possessing ASAT weapons, operational or under construction (the United States and the Soviet Union)—and other States which either have civil space programmes or, whether or not they possess those, in any event do not have anti-satellite capacity. The desirable régime would have to establish a minimum measure of common ground among all the parties concerned.

First of all, the hypothetical conclusion of a Soviet-American bilateral agreement concerning ASAT weapons cannot be ruled out. However, such an agreement would not necessarily mean reducing the risks which the ASAT systems of these two countries represent for the safety of the satellites of third countries; the agreement would only amount to *de jure* recognition of the present imbalance in favour of the United States and the USSR.

Secondly, it is cause for concern that a multilateral approach would either be rejected by one or other of the Powers possessing ASAT, or would be taken up by one of them for use as a platform from which to denounce the adversary's military programmes. In this respect, the way in which the latest Soviet proposals in favour of the establishment of a world space organization were formulated is significant.

To bypass these political stumbling-blocks and to try to overcome the technical difficulties inherent in the nature of the ASAT problem, it is desirable that an international régime should be set up designed to reduce the tension and uncertainty which these days surrounds space activities and to prevent the emergence of situations of conflict prompting recourse to anti-satellite systems.

The establishment of such a régime would presuppose:

(*a*) Improving the *legal principles* aimed at limiting the ASAT threat;

(*b*) Working out *confidence-building measures* applicable to:

- (i) States already involved in space activities, enabling them to develop these activities in a climate of greater security and thus to underline the peaceful destiny of space;
- (ii) All other States, particularly the developing States, with a view to facilitating their access to the benefits of space use and encouraging international co-operation in the field of space activities.

1. Legal principles

Prevention of an arms race in outer space is currently essentially a composite régime, since it combines three categories of principles and obligations which somewhat overlap:

Those which derive from the 1967 Outer Space Treaty, governing access by all to space, and the 1970 Convention on the Registration of Objects Launched into Outer Space;

Those resulting from the automatic extension to space of partial limitations on military activities on earth and which in fact constitute the main purpose of those multilateral instruments;

Those deriving from the Soviet-American bilateral régime, emphasizing the interrelationship between military activities in space and all the other factors governing the overall strategic relationship between the United States and the Soviet Union.

As we saw in Chapter III of this report, the outcome of this overlapping of norms is by no means satisfactory. Apart from the prohibition of deployment in space of arms of mass destruction (the 1967 Treaty) and that of outer space nuclear tests (the 1963 Treaty), it has not been possible to avoid militarization of space, in the sense of the placement of military systems into orbit.

Consequently, it does not seem realistic to try to base an international régime for controlling anti-satellite systems on the principle of banning ASAT weapons. This approach will therefore not be adopted in the recommendations in this report.

The idea of banning ASAT systems out of hand would in actual fact seem inapplicable. Measures of prohibition declaring the possession of ASAT weapons illegal are too general, abstract and not verifiable, and would not be in keeping with the nature of the problem. The main reason is bound up with the logic of acquired rights. For both political and military reasons, no State concerned would agree to give up the ASAT capacity it already possesses nor its right to try to obtain that capacity if it felt threatened.

With regard to the use of ASAT weapons, which in general is prohibited by virtue of the principle of the prohibition on the use of force in international law, it is still permissible in situations of self-defence. In this respect, the 1925 Geneva Protocol and the reservations to it issued by the Parties, forbidding the use of chemical weapons while leaving open the possibility of a response in kind in the event of a first strike by the other Party, could be cited by way of precedent. It would seem, however, that even the ban on first use would in no way reduce the threat posed by the development of ASAT systems.

The notion of citing the ABM Treaty to prohibit ASAT weapons does not appear to warrant adoption, for the very good reason that the present régime applied to anti-ballistic missile systems is inadequate. The 1972 Treaty does not establish an absolute prohibition, but merely limits American and Soviet anti-ballistic missile capacity, and deals only indirectly with research (thus giving rise to the present controversy over the "liberal" or "restrictive" interpretation of the Treaty clauses). Since this régime applies only to the United States and the USSR, it cannot cater for the need to protect third-party space systems, as advocated in this report. Moreover, the political and technological uncertainty that jeopardizes the future of the 1972 Treaty, in particular because of the American Strategic Defense Initiative and the Soviet ABM programmes, makes it impossible to use that Treaty as a model for ASAT.

At the other extreme, the notion of selective or global immunity of potential targets likewise does not seem to be an appropriate basis for setting up a legal system to regulate the ASAT systems race. Global immunity would seem to be unrealistic. It would amount to making all use of ASAT weapons unlawful, which is out of the question for the reasons mentioned above. Nor does a selective immunity régime seem to be desirable. It would amount to setting up a régime of inequality between the various space activities and would, ultimately, have the opposite effect of designating the whole series of satellites not enjoying immunity as potential targets. This would amount to perpetuating the inadequacies of the present régime, under which only certain American and Soviet space systems (the National Technical Means of Verification of the SALT I and II Agreements and the ABM Treaty) enjoy strict bilateral immunity.

Another way of regulating the development of ASAT systems might be to create differentiated space zones, some (low orbits already within the reach of the existing ASAT weapons) open to anti-satellite activity, others (high orbit and particularly geostationary) closed to any ASAT activity. This approach has serious drawbacks. In the first place, the creation of orbital zones with a particular legal status would pose extremely complex problems of verification (delimitation of zones, ASAT devices usable in both low and high orbit, etc.). Furthermore, the institution of such a differentiation would presuppose a too extensive and politically unrealizable reformulation of the present legal system. In particular, it would bring about a stratification of space, even though there is no geographical delimitation recognized at present between outer space and airspace.

Inasmuch as the solutions we have just reviewed do not appear to warrant adoption, other foundations must be sought for the régime of protection of satellites against anti-satellite systems.

Given the impossibility of bringing about a global agreement on the entire anti-satellite domain, the object pursued would be first and foremost to avoid anarchic proliferation of ASAT systems. To provide greater safety for inoffensive space systems, concrete measures might be taken to stabilize relations between space users. Initially, it would be desirable within the framework of space law, to reaffirm and develop the principle of non-interference with inoffensive space activities, as recognized by article IX of the 1967 Outer Space Treaty.

It would also be helpful to reaffirm the basic principles of the legal régime of space, namely freedom of movement, exploration and utilization of outer space on an equal footing by all, involving non-discrimination among States and non-appropriation of space.

2. Confidence-building measures

Without purporting to eliminate every form of ASAT threat, the gradual adoption of such measures would make it possible to introduce more *transparency* into the space activities of States and to create a climate of confidence needed for the *stabilization* of relations between the various users of space systems. The measures may be helpful in avoiding the type of confusion and uncertainty which could generate misunderstandings and incidents in orbit.

Two series of measures might be considered: improvement of the procedure for registration and notification of space objects.

Improvement in the registration procedure

This involves additions to the existing régime set up under the 1975 Convention on Registration of Space Objects. States would be invited to describe each of their space missions more precisely, communicating to an international authority (the Secretary-General of the United Nations as under the present régime or a new international agency devoted to space activities) detailed data on the space objects placed in orbit.

An arrangement of that kind would be particularly helpful in improving the capability for detecting the deployment in space of ASAT devices such as space mines or interceptor satellites. For example, without the need to revise the 1975 Convention, space users might voluntarily furnish the following supplementary information on space objects:

More detailed information on the type of space vehicle (scientific or applied functions satellites, platforms, space probes, orbital transport vehicles, etc.);

A description thereof (space station, manned vehicle, unmanned vehicle, automatic) *and its intended lifespan*;

Its orbital features (apogee, perigee, inclination in relation to the equator, period, perigree variables, length of the ascending node). It would be desirable for any change in one or more of these features (particularly in the event of manœuvres in orbit) to be reported;

Physical characteristics (dimensions, volume, mass);

The mass of ergols carried (potentially aggressive satellites carry considerable masses of ergols making changes in orbit possible);

Type and level of energy production (in particular, nuclear energy production systems) *and the presence on board of materials dangerous to other satellites*;

Name and address of the body responsible for operation and launching.

The information furnished would give the international community a better understanding of the nature of the space missions conducted by the various States and would thus help to improve the level of information available concerning their space activities. Obviously the effectiveness of these measures would depend on the good faith of States, in view of the lack of reliable means of verification.

Strengthening of the launch notification requirement

This can be envisaged in three ways:

Annual notification of intent. Each State would be invited to submit at least once a year (for example, at the beginning of each calendar year) a list of launchings it proposes to carry out during the year. The list could include an estimate of the number of foreseeable orbits and a provisional time-table of launchings.

Final notification. This could take place within a few days prior to the launching and at the latest by the actual day on which it occurs; and it could be supplemented by information concerning the progress of the mission (accidents in orbit, circumstances of return to Earth, etc.). The international community would thus be kept abreast almost daily of the status of the space activities of each State.

Changes in orbit. It might also be desirable to consider notification of any significant change in orbit. On the basis of a number of criteria, on the definition of which the parties might reach agreement, any significant change in orbit (or in position in orbit, in the case of geo-stationary satellites) might be treated as a new launching. Such a measures might, for example, be useful in circumscribing the activities of space mines.

Code of conduct

The idea here would be to protect space systems by establishing a series of *rules of behaviour* for States in the context of their space activities. Such measures, based on the principle of non-interference, would constitute a *real multilateral code of conduct* applicable to space activities. Each State would at once have the right not to be hampered in carrying out its space activities and in turn the obligation to refrain from carrying out, in space or from the ground, activities which hamper or endanger the space systems of other countries.

In this connection, a parallel with the conclusions of the Conference on Confidence and Security-Building Measures and Disarmament in Europe (CDE) on measures of security and confidence in Europe might be invoked. As in the framework of the Stockholm Agreements of September 1986, the parties concerned would by common consent grant a right of mutual inspection of their respective space activities.

This code of conduct might include among other things the drafting of a code of conduct of *orbital activities* and a system of *space protection*. By way of example, five specific measures might be envisaged.

Regulation of manoeuvres in orbit and an internationally accepted definition of rules of approach

In particular, the limitation of approaches within the lethal radius of space objects and the surveillance or prohibition of satellites permanently following other space objects (with a view to eliminating the danger of space mines) would be proposed.

The definition of safety zones

With regard to the definition of *rules of approach* to be observed between satellites or other space objects, States should reach agreement on the precise definition of such approaches, bringing in not only the notion of geographical distance (since the remoteness of satellites describing different orbits is not fixed), but also the notion of the minimum time spent by space objects close to one another. These rules would be based, especially in regard to satellites in geo-stationary orbit, on the pertinent work of ITU and without prejudice thereto.

There should be an internationally accepted definition of *zones of approach* within which a right of way might be guaranteed, although subject to very precise rules of conduct. The legal system would determine which objects could be allowed into these zones and under what circumstances, and might also define the right to inspect them or to require the withdrawal of the object infringing the rules of approach.

Alerting devices

It might be useful to develop devices for determining at regular intervals the trajectory and the status of objects in space. They would form part of a ground control network under an international space activities authority. The development of an anti-collision surveillance system might be considered in the same context. The development of devices to enable any space vehicle itself to discover the presence of a suspect object in its proximity does not seem feasible because of the technical difficulties and the cost.

Establishment of a space environment protection régime

This measure is based on the idea of prohibiting tests, and more especially the development of ASAT systems, prone to pollute the environment both in space and on land. It would be aimed particularly at ASAT weapons which either by exploding in the proximity of the target or by shooting the target to pieces produce long-lasting orbital debris likely among other things to affect the proper functioning of third-party satellites in the neighbourhood.

It would of course be necessary to discover how this type of restriction would be received by the United States and the Soviet Union, which possess such systems. It seems likely, however, that the difficulties encountered in formulating general measures for limiting ASAT weapons would not recur, since the purpose here would be to bring about a concerted undertaking not to pollute space, essentially because at some levels of altitude such pollution has already reached an almost critical stage.

Limits on ASAT experimentation

While it is virtually impossible to determine the parameters of the overall space activities of States, the notion of fixing maximum levels of ASAT experimentation would seem worth considering with a view to avoiding the anarchic proliferation of anti-satellite systems. The development of such a measure would presuppose first and foremost the establishment of precise criteria for defining ASAT activities. Furthermore, the question of the compliance of such a rule with the principle of the free use of outer space would have to be studied.

3. An international space agency

The establishment of an international space agency would constitute one of the confidence-building measures designed to favour international co-operation in outer space aimed both at States carrying out space activities and States not yet enjoying the benefit of the uses of space. It is obvious that this could only take place if, as the first two points recommended by this report (reaffirmation of legal principles and establishment of a code of conduct for space activities) were to materialize so as to provide a suitable political climate.

The idea of setting up a world space organization has gained considerable momentum since the UNISPACE Conference in Vienna in 1982 (note the interest expressed by the countries of the Group of 77 and Soviet proposals). Concrete precedents can be cited, since in comparable spheres (aviation, atomic energy, ocean transport, data processing) there are already organizations of this kind).

The purpose of the Agency would be to promote international solidarity in the sphere of peaceful uses of outer space and to safeguard the principles of free exploration and non-appropriation of outer space, as well as to facilitate access by all States, particularly developing countries, to the benefits to be derived from the use of space. It would not be designed to channel privatization of space activities, but to support and develop the space programmes of all States, on a broad international basis. In other words, it is desirable to avoid allowing such an organization to lead to excessive politicking in the sphere of outer space.

On the *financial level*, substantial manpower and budgetary means already exist within the framework of various international bodies, whether or not they belong to the United Nations system. The aim here would be to better co-ordinate existing resources, so as to utilize them in the most effective manner.

At the *structural level*, it would be beneficial for such a space organization to depart from the classic type of structure in accordance with the rules governing international organizations and instead to draw inspiration from the innovations introduced by the international organizations for space telecommunications. The latter, such as INTELSAT and INMARSAT, are examples of organizations based on new legal techniques which in particular provide for *representation* not only by States but also by technical bodies or administrations (such as the national or regional space agencies), as well as for *operating principles* based on economic considerations.

The new agency would thus be distinguished from the classic type of international organization based on the principle of exclusive representation by States, the principle of "one State one voice" and the principle of exclusively budgetary financing of activities.

These legal formulae would, however, only be valid in the event of the world space agency being devoted to assisting countries in the field of peaceful activities and not in the control of space weapons or the elaboration and development of international space law. In these two latter domains, it would seem preferable to leave it to the Committee on the Peaceful Uses of Outer Space (and its legal Sub-Committee) and the Conference on Disarmament to carry out those tasks.

The *technical status* of the agency needs to be underlined. It should be an operational body capable of handling a whole series of concrete problems.

In the sphere with which were are concerned, the new Agency would help to ensure the safety of space systems by administering the application of transparency and *confidence-building measures and by supervising the observance by States of the code of conduct in space activities.*

Several ways in which the Agency might act can be envisaged:

It would be responsible for the *international registration* of space objects, maintaining a genuine data bank on the space activities of member States. The information kept by the Agency would be available to any member State requesting it.

The Agency would also undertake to establish *space object surveillance and control networks* and would be in charge of *space observation centres on land*, set up with contributions from the international scientific community.

The role of the Agency might in due course evolve in the direction of *certain forms of inspection*. Ultimately, international teams of inspectors appointed by and dependent on the Agency, rather like those of IAEA, might be set up. They would be responsible for the task of checking on the spot (by visits to research centres, assembly plants and launching sites) whether the space activities of the member States were in conformity with international rules.

It might also *intervene as mediator* in confrontations between parties faced with violations of the code of conduct, and help them to find a consensus solution. This function might be performed either by a standing organ of the Agency (for example, along the lines of the Standing Consultative Commission established by the ABM Treaty of 1972), or by an *ad hoc* commission nominated by the parties under the control of the Agency.

*

* *

The thought process which has inspired the recommendations at the conclusion of this report on anti-satellite systems, is based on three motivating conceptions, as follows:

The first of these deliberately discards the notion of prohibiting ASAT systems. In the conviction that such a ban could not be implemented in practice (even supposing that the interested States could reach agreement on such a formula), the approach adopted here is based on the belief that substantial security for space systems could be best achieved by the introduction of a series of partial, prudent and concrete measures designed to bring about greater security in the environment in which States carry out their space activities.

The second pivotal point of this thinking about the ASAT problem is the conviction that it is both desirable and possible to get States to observe a minimum of rules in the interests of a common objective. Underlying this approach, which favours the "peaceful" utilization of space (civil satellites, non-offensive military satellites, etc.), is a grave concern about the consequences that the development of anti-satellite systems may have on the pursuit of peaceful space activities, which henceforth are bound to be extremely important for the international community as a whole. The question of ASAT weapons would therefore seem to be inseparable from other problems relating to the conduct of space activities by States, and its solution must be found in a multilateral framework. The idea of "transparency" and a "code of conduct", the definition of precise rules of behaviour in space, and the reaffirmation of the main fundamental principles of the law of outer space could thus help not only to reduce the anti-satellite threat; it could also form part of an overall process leading towards a more satisfactory regulation of the uses of space.

The third key conception derives from a sense of realism and economy. Instead of proposing an *ad hoc* régime of regulation and control of ASAT activities, it is proposed to make maximum use—in conjunction with their expansion and integration—of the legal instruments and institutions already existing in the sphere of space activities.

There is no doubt that the measures proposed here will seem to some people too modest (as compared, for example, with a possible—but illusory—total ban on all ASAT systems), and to others sitll over-ambitious (in relation to the moves already under way between the USA and the USSR). They will nevertheless help—and that is the essential purpose of the present report—to provide a useful beginning to a debate which concerns the international community as a whole.

ANNEXES

Annex I

COMPARISON BETWEEN THE AMERICAN AND SOVIET ASAT WEAPONS

TABLE 1

Soviet ASAT tests, 1968-1982

Phase	Test number	Date	Target	Target orbit: Inclination (degrees)	Target orbit: Perigee (km)	Target orbit: Apogee (km)	Interceptor	Intercept orbit: Inclination (degrees)	Intercept orbit: Perigee (km)	Intercept orbit: Apogee (km)	Attempted intercept altitude (km)	Mission Type	Probable outcome
Phase I	1.......	20 Oct. 68	K248	62.25	475	542	K249	62.23	502	1 639	525	2 Rev	Failure
	2.......	1 Nov. 68	K248	62.25	473	543	K252	62.34	535?	1 640?	535	2 Rev	Success
	3.......	23 Oct. 70	K373	62.93	473	543	K374	62.96	530	1 053	530	2 Rev	Failure
	4.......	30 Oct. 70	K373	62.92	466	555	K375	62.86	565	994	535	2 Rev	Success
	5.......	25 Feb. 71	K394	65.84	572	614	K397	65.76	575?	1 000?	585	2 Rev	Success
	6.......	4 Apr. 71	K400	65.82	982	1 006	K404	65.74	802	1 009	1 005	2 Rev	Success
	7.......	3 Dec. 71	K459	65.83	222	259	K462	65.88	231	2 654	230	2 Rev	Success
Phase II	8.......	16 Feb. 76	K803	65.85	547	621	K804	65.86	561	618	575	1 Rev	Failure
	9.......	13 Apr. 76	K803	65.86	549	621	K814	65.9?	556?	615?	590	1 Rev	Success
	10.......	21 July 76	K839	65.88	983	2 097	K843	–	–	–	1 630?	2 Rev	Failure[a]
	11.......	27 Dec. 76	K880	65.85	559	617	K886	65.85	532	1 266	570	2 Rev	Failure[b]
	12.......	23 May 77	K909	65.87	993	2 104	K910	65.86	465?	1 775?	1 710	1 Rev	Failure
	13.......	17 June 77	K909	65.87	991	2 106	K918	65.9?	245?	1 630?	1 575?	1 Rev	Success[c]
	14.......	26 Oct. 77	K959	65.83	144	834	K961	65.8?	125?	302?	150	2 Rev	Success
	15.......	21 Dec. 77	K967	65.83	963	1 004	K970	65.85	949	1 148	995	2 Rev	Failure[b]
	16.......	19 May 78	K967	65.83	963	1 004	K1009	65.87	965	1 362	985	2 Rev	Failure[b]
	17.......	18 Apr. 80	K1171	65.85	966	1 010	K1174	65.83	362	1 025	1 000	2 Rev	Failure[b]
	18.......	2 Feb. 81	K1241	65.82	975	1 011	K1243	65.82	296	1 015	1 005	2 Rev	Failure[b]
	19.......	14 Mar. 81	K1241	65.82	976	1 011	K1258	65.83	301	1 024	1 005	2 Rev	Success
	20.......	18 June 82	K1375	65.84	979	1 012	K1379	65.84	537	1 019	1 005	2 Rev	Failure[b]

Source: Nicholas Johnson, *The Soviet Year in Space, 1983*, Colorado Springs, Teledyne Brown Engineering, 1984, p. 39.

K = Kosmos.

NOTE. The question marks indicate an approximate evaluation.

[a] Apparently failed to enter intercept orbit.

[b] Reportedly used new optical sensor.

[c] Conflicting data exist for intercept orbit.

TABLE 2

American ASAT tests, 1959-1984

No.	*Date*	*Programme title*	*Service*	*Location*	*Outcome*
1..............	13 Oct. 59	Bold Orion	Air Force	Eastern Test Range	Success
2..............	6 Apr. 62	Hi He	Navy	Pacific Test Range	Failure
3..............	26 July 62	Hi He	Navy	Pacific Test Range	Success
4..............	17 Dec. 62	Program 505 (Mudflap)	Army	Whale Sands N.M.	Success
5..............	15 Feb. 63	Program 505	Army	Whale Sands N.M.	Success
6..............	21 Mar. 63	Program 505	Army	Kwajalein Atoll	Failure
7..............	19 Apr. 63	Program 505	Army	Kwajalein Atoll	Failure
8..............	24 May 63	Program 505	Army	Kwajalein Atoll	Success
9..............	6 Jan. 64	Program 505	Army	Kwajalein Atoll	Success
10..............	14 Dec. 64	Program 437	Air Force	Johnston Island	Success
11..............	2 Mar. 64	Program 437	Air Force	Johnston Island	Success
12..............	– Apr. 64	Program 505	Army	Kwajalein Atoll	Success
13..............	21 Apr. 64	Program 437	Air Force	Johnston Island	Success
14..............	28 May 64	Program 437	Air Force	Johnston Island	Failure
15..............	16 Nov. 64	Program 437 (CTL)[a]	Air Force	Johnston Island	Success
16..............	5 Apr. 65	Program 437 (CTL)	Air Force	Johnston Island	Success
17..............	– June-July 65	Program 505	Army	Kwajalein Atoll	Success
18..............	– June-July 65	Program 505	Army	Kwajalein Atoll	Success
19..............	– June-July 65	Program 505	Army	Kwajalein Atoll	Success
20..............	– June-July 65	Program 505	Army	Kwajalein Atoll	Failure
21..............	7 Dec. 65	Advanced Program 437	Air Force	Johnston Island	N/A
22..............	13 Jan. 66	Program 505	Army	Kwajalein Atoll	Success
23..............	18 Jan. 66	Advanced Program 437	Air Force	Johnston Island	N/A
24..............	12 Mar. 66	Advanced Program 437	Air Force	Johnston Island	N/A
25..............	2 July 66	Advanced Program 437	Air Force	Johnston Island	N/A
26..............	30 Mar. 67	Program 437 (CEL)[b]	Air Force	Johnston Island	Success
27..............	15 May 68	Program 437 (CEL)	Air Force	Johnston Island	Success
28..............	21 Nov. 68	Program 437 (CEL)	Air Force	Johnston Island	Success
29..............	28 Mar. 70	Program 437 (CEL)	Air Force	Johnston Island	Success
30..............	25 Apr. 70	Special Defense Program	Air Force	Johnston Island	Failure
31..............	24 Sep. 70	High Altitude Program	Air Force	Johnston Island	Success
32..............	21 Jan. 84	PMALS[c]	Air Force	Western Test Range	Success
33..............	13 Nov. 84	PMALS	Air Force	Western Test Range	Success

Sources: Paul Stares, *The Militarization of Space: U.S. Policy 1945-1984,* Ithaca, New York, Cornell University Press, 1985, p. 261.

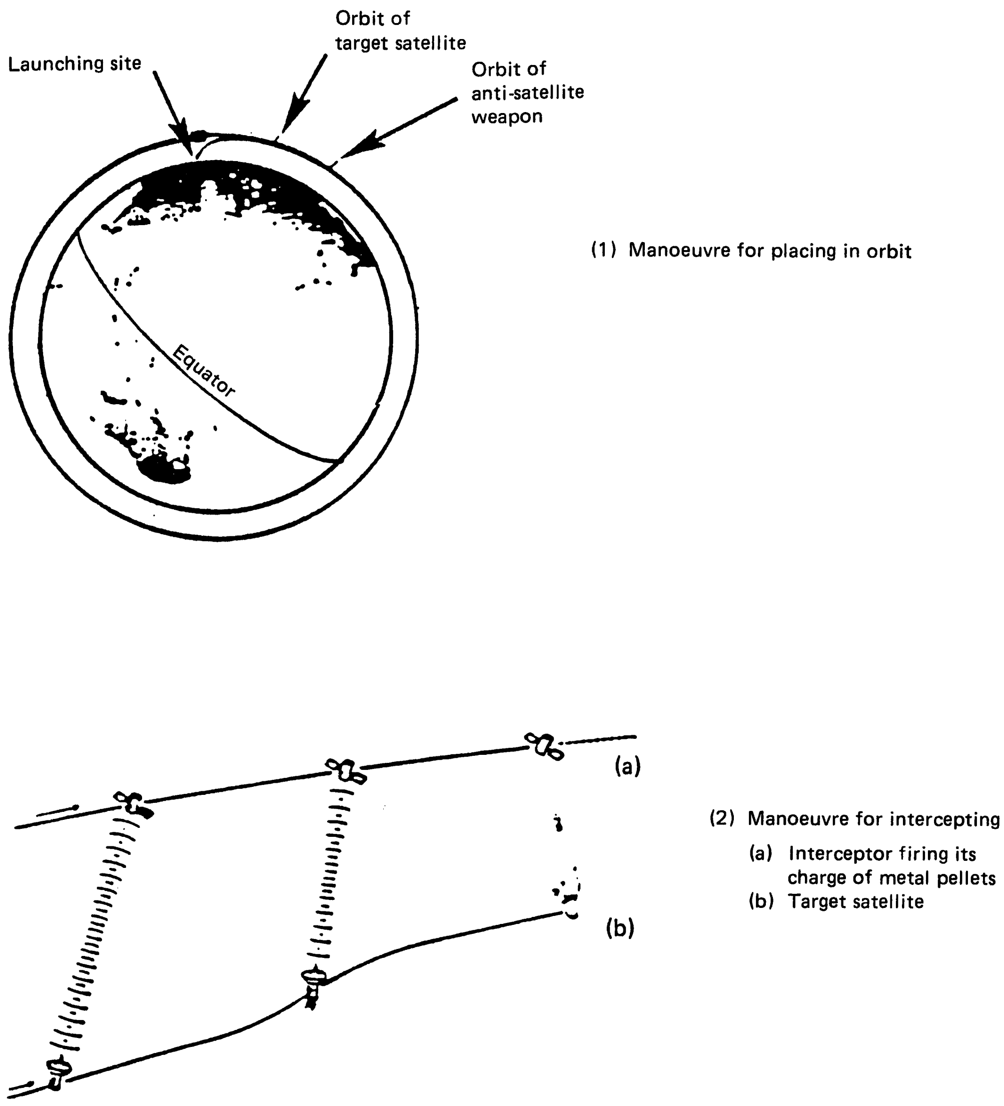
[a] CTL = Combat test launch.

[b] CEL = Combat evaluation launch.

[c] PMALS = Prototype miniature air launched system.

FIGURE I

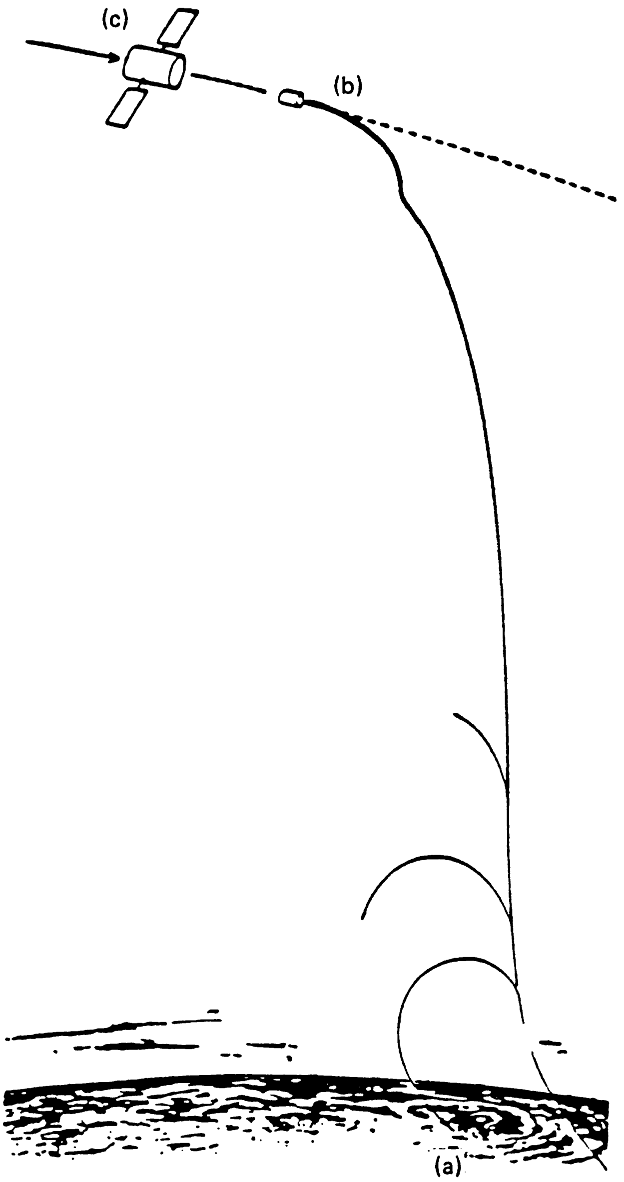
The technique of co-orbital interception (Soviet ASAT)



Source: R. Garwin, K. Gottfried and D. Hafner, "Antisatellite Weapons", *Scientific American*, June 1984.

FIGURE II

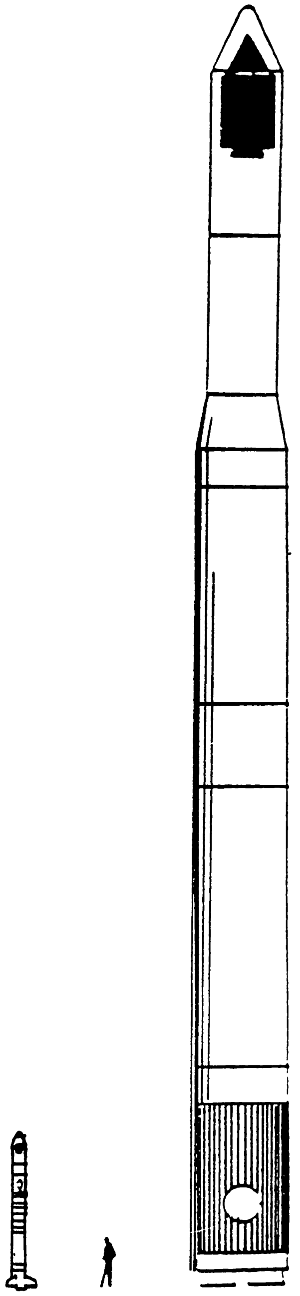
The technique of interception by direct ascent
(American ASAT)



Source: R. Garwin, K. Gottfried and D. Hafner, "Antisatellite Weapons", *Scientific American*, June 1984.

Figure III

Comparative size of the American and Soviet ASAT weapons



(a) (b)

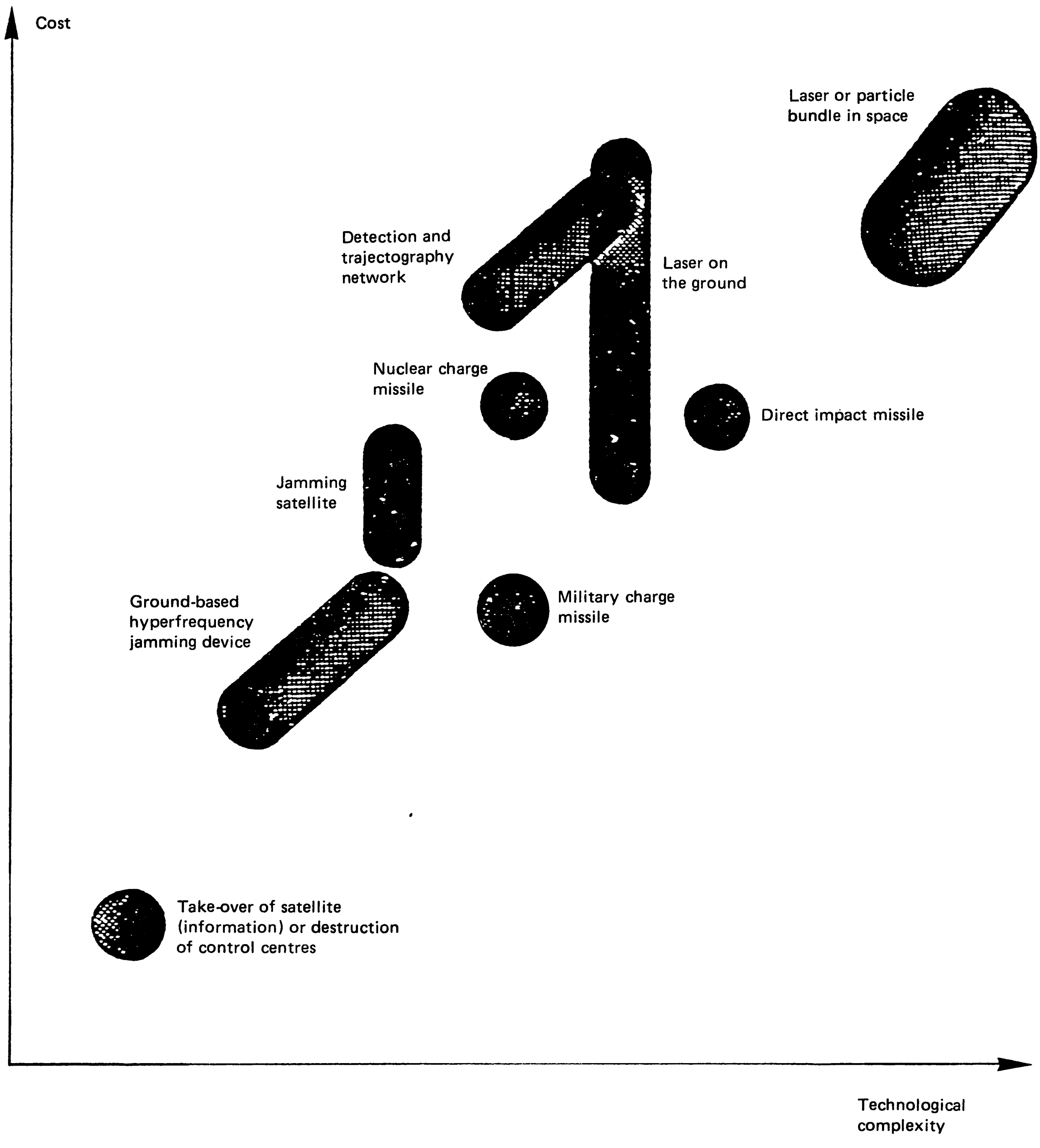
(a) American F-15 launched SRAM/MHV interceptor
Length: 5.4 m
Weight: 1200 kg

(b) Soviet SS-9 rocket with
interceptor-satellite
Length of rocket: 45 m
Length of interceptor: 6 m
Interceptor weight: 2000 kg

Source: R. Garwin, K. Gottfried and D. Hafner, "Antisatellite Weapons", *Scientific American*, June 1984.

FIGURE IV

Comparison of the different ASAT systems



Annex II

OUTLINE OF PROPOSALS FOR COPING WITH ANTI-SATELLITE WEAPON SYSTEMS

I. Initiatives with a view to the prohibition of ASAT weapon systems

1. *Italian proposal (1979)*

Disarmament Conference (United Nations), March 1979.

Document proposing an additional protocol to the Space Treaty of 27 January 1967.

This would limit the use of space in general to exclusively peaceful ends, thus filling the gap left by article IV of the 1967 Treaty.

2. *Soviet proposal for a treaty (1981)*

General Assembly of the United Nations, thirty-sixth session, August 1981.

Document entitled "Draft Treaty on the Prohibition of the Stationing of Weapons of Any Kind in Outer Space" (9 articles).

Article 1 (1) would prohibit the placing in orbit or on celestial bodies of any object carrying weapons, including re-usable space vehicles, present or future (shuttle type).

Article 3 would prohibit the total or partial destruction of, interference in the normal functioning of, and modification of the trajectory of, any object placed in space in accordance with article 1 (1) above.

3. *Pressler resolution (1981)*

United States Senate resolution introduced by the Republican Senator L. Pressler and adopted in May 1981.

Proposes the adoption of a Soviet-American agreement establishing a complete ban on the use of ASAT weapons, an unlimited moratorium on testing them, and the dismantling of all existing ASAT systems.

4. *Tsongas resolution (1983)*

United States Senate resolution introduced by the Republican Senator P. Tsongas and adopted in February 1983.

Proposes the negotiation of a bilateral Soviet-American treaty forbidding the testing, manufacture, deployment or use of any weapon system designed to damage, destroy or put out of action the space objects of any country, whether based in space, in the air or on the ground.

Requests the President of the United States to sponsor a conference for the revision of article IV of the Space Treaty of 27 January 1967.

5. *Proposal by the Union of Concerned Scientists (1983)*

Document entitled "Treaty on the Limitation of Anti-Satellite Weapons", May 1983 (12 articles).

Takes over the contents of the Tsongas resolution of 1983 but allows the maintenance and deployment of existing ASAT systems, while forbidding operational testing thereof.

6. *Second Soviet proposal for a treaty (1983)*

General Assembly of the United Nations, thirty-ninth session.

Document entitled "Treaty on the Prohibition of the Use of Force in Outer Space and from Space against the Earth".

Article 1 takes up the wording of Article 2 (4) of the Charter of the United Nations, while prohibiting recourse to the threat or use of force in outer space.

Article 2 takes up the Soviet proposal of 1981, supplementing it with a ban on the testing and construction of new ASAT systems and the destruction of existing systems.

Article 3 of the 1981 proposal is suppressed, but the use of manned space vehicles able to be used for military purposes is still prohibited.

7. *Bowman proposal (1984)*

Semi-official Soviet-American conference "Space without Weapons", held in Moscow in April 1984.

American document entitled: "Proposed Revised Traty on the Prohibition of the Use of Force in Outer Space and from Outer Space with regard to Earth".

Combination of the Soviet proposals of 1983 and those of the Union of Concerned Scientists (1983), supplemented by a ban on ASAT systems based on the ground or in the air.

Summarizing the seven main proposals put forward to date, four types of ban on ASAT weapon systems are evident:

Ban on the testing, use and possession of all ASAT capacity;

The same ban, but limited to systems which are ASAT systems by destination (ASAT weapons properly so-called);

Ban on the development, testing and use of future ASAT technologies, leaving the existing systems intact;

Ban on use only, ignoring the testing and possession of ASAT systems.

II. Initiatives with a view to the limitation of ASAT weapon systems

1. *Limitation of operation capacity at altitude*

Proposal by the former Canadian Primer Minister P. E. Trudeau in December 1983 for limiting ASAT systems to low orbit only.

This proposal was taken up in the report by the Reagan Administration to Congress on the control of ASAT weapons in April 1984 as a possible meeting ground for negotiations with the Soviet Union.

It should be noted that limitation to the already existing ASAT systems amounts also to a ban on ASAT weapons in high orbit.

2. *The French position (1984)*

Disarmament Conference (United Nations), June 1984.

Proposal, in the form of a working document, to prevent the introduction of new weapons into space through progressive limited but verifiable agreements.

Four important points:

A. Strict prohibition of all ASAT systems operational in high orbit.

B. Prohibition for five years, renewable, of the testing and deployment of directed energy weapons based on the ground, in the air or in space, whether intended for ASAT or for ABM functions.

C. Reinforcement of the 1975 Convention on Registration of Objects Launched into Outer Space.

D. Extension to the satellites of third countries of the Soviet-American bilateral immunities in force.

3. *Dahlitz proposal (1985)*

Document entitled "Treaty on the Prohibition of the Use of Force Concerning Outer Space", produced by Dr. J. Dahlitz (Bradford University, England).

Article 1 forbids any interference with a space vehicle of another State, but authorizes testing against targets belonging to a State making tests.

The only ban is that on testing and deployment of kinetic energy weapons intended for ASAT or ABM purposes, wherever they may be based. Directed energy weapons are not included, but the article reiterates the observance of the clauses of the ABM Treaty of 1972.

4. *Proposal by A. B. Carter (1986)*

Article by A. B. Carter in the last issue of *International Security* (Spring 1986).

Three essential proposals:

A. To forbid ASAT interceptors using kinetic energy at any altitude above 3000 km (low orbit).

B. To forbid ASAT interceptors using directed energy stationed in space at any altitude above 1000 km (low orbit).

C. To set up exclusion zones round satellites in semi-synchronous or geo-stationary orbit.

III. Initiatives in the form of "confidence-building measures" in the face of the ASAT threat

Some writers advocate "confidence-building measures" which could constitute a real "code of conduct" in relation to the space activities, military or civil, of States.

All these measures are based on two bilateral Soviet-American conventions on the subject: Agreement on Measures relating to the Risks of an Accidental Nuclear Conflict, 1971, and Agreement on the Prevention of Incidents at Sea, 1972.

Six types of essential measures can be inferred from these proposals: institution of minimum separation between satellites in orbit or of exclusion zones around them; possibility of inspection in orbit; regulation of orbital rendezvous operations or closely similar flight speeds; prior announcement of certain launchings, to strengthen the 1975 Convention on Registration of Space Objects; and finally, on-the-spot inspection prior to launching.

IV. Soviet proposals for a world space organization

1. *Soviet proposal of 1985*

Letter from the Soviet Foreign Minister to the Secretary-General of the United Nations, dated 15 August 1985.

Draft resolution by the General Assembly of the United Nations entitled "International Co-operation in the Peaceful Exploitation of Outer Space under Conditions of its Non-Militarization.

Proposes the establishment of a world space organization to co-ordinate the peaceful space activities of States, and in particular to ensure access to space by developing countries.

Suggests the convening, by 1987 at tne latest, of an international conference for the purpose of working out in depth the principles of the peaceful exploitation of space and setting up the above-mentioned organization.

2. *Soviet "Star Peace" proposal, 1986*

Message from the President of the Council of Ministers of the USSR to the Secretary-General of the United Nations, dated 12 June 1986.

Programme of action in three stages for the purpose of establishing "between now and the year 2000 the concrete political, legal and organizational bases of the 'Star Peace' initiative" comprising:

- By 1990, the convening of an international conference or a special session of the General Assembly devoted to the problems of space and the establishment, under the auspices of the United Nations, of a world space organization.
- Between now and 1995, the establishment of international programmes for the scientific exploration and the technical utilization of space.
- Between now and the year 2000, the establishment of a genuine world policy for space, with programmes and infrastructures at international level.

Annex III

VERIFICATION OF AN ASAT AGREEMENT

Types of ASAT weapon	*Development*	*Testing*	*Deployment*	*Utilization*	*Remarks*
Attacking the satellite					
Projectile striking satellite directly	Difficult	Easy	Very difficult	Very easy	
Projectiles with military charge firing shrapnel against the satellite	Difficult	Easy	Very difficult	Very easy	
Relativistic weapons (laser, particle bundle)	Difficult	Difficult	Difficult	Difficult/Easy*	* According to the way they are used (damage reversible or slow, or to destruction)
Nuclear charge exploded near by	Difficult	Not necessary	Very difficult	Easy	
Attacking certain components of the satellite					
Payload: Optical instruments; Telecommunication repeater; Power system; Telemetry/remote control system; Attitude control system	Difficult	Difficult	Difficult	Difficult/Easy*	* According to the way they are used (damage reversible or slow, or to destruction)
Ground-satellite-linked					
Jamming of remote control links; Sending out of false orders; "Take-over" of the satellite	No specific development*	Not necessary	Difficult if not impossible	Easy	* This is an information problem
Satellite-ground-linked					
Jamming of telemetry links; Sending out of false information	Not necessary (see above)	Not necessary	Fairly easy*		* The satellite close by may for a long time seem harmless
Ground-based					
Launching sites; Control centres; Telecommunication or telemetry/remote control centres	Not necessary*	Not necessary*	Pointless	Easy*	* Commandos

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