Legal Regimes for the Mining of Helium-3 from the Moon

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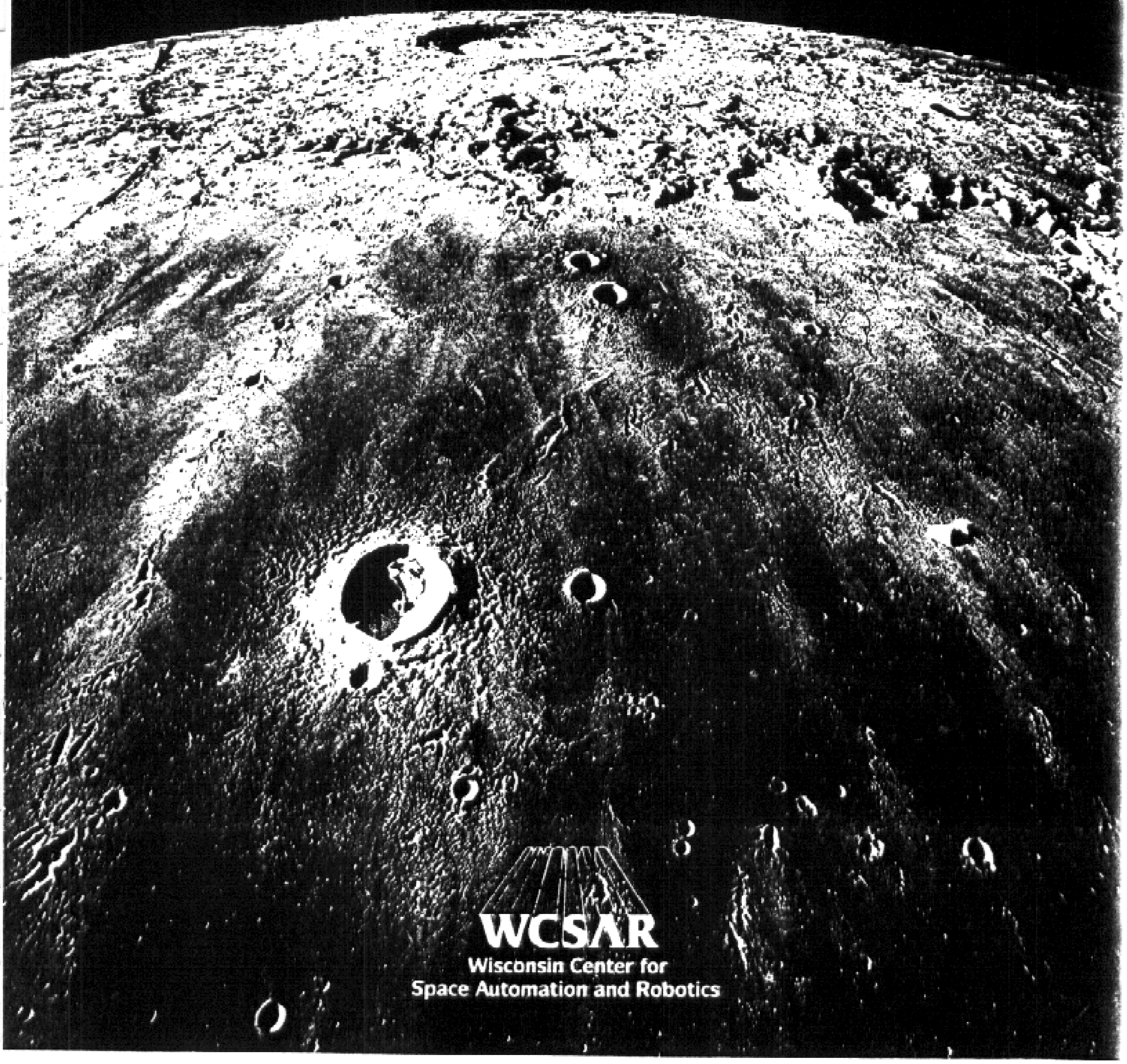

WCSAR
Wisconsin Center for
Space Automation and Robotics

LEGAL REGIMES FOR THE MINING

OF HELIUM-3 FROM THE MOON

by

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PREFACE

The need for studies of legal regimes for the mining of lunar helium-3 was apparent in 1985 when the first connection was made between lunar helium-3 and the world thermonuclear fusion program. It seemed obvious that any large scale application of an advanced fusion fuel cycle using helium-3 would require substantial mining activities on a body which, by treaty, belongs to no one, and a legal framework would have to be in place before any nation or private entity could commit the resources necessary for such an endeavor.

In 1986, officials at the United States National Aeronautics and Space Agency (NASA) initiated funding at the University of Wisconsin to study the commercial promise of the deuterium-He3 fuel cycle. This was done through NASA's Office of Commercialization (Code C). By 1988, enough information was available on the positive technical, financial and environmental aspects of this fuel to initiate a study into the legal aspects of such an endeavor. Dr. Ray Whitten, Manager of the Centers for the Commercial Development of Space (CCDS) for the Office of Commercialization, commissioned such a study in the summer of 1988 and this report summarizes the results of that work.

The extensive nature of this project indicated that a wide variety of technical and legal disciplines would be required to write a final report. The necessary areas of expertise range from nuclear physics to international law with the topics of space, mining and economics in between. The four individuals who authored this document cover all of those disciplines, but as in any endeavor involving such a wide spectrum of backgrounds, specific sections of this report were initially written by one member of the group. Every chapter was then subjected to internal review by all the authors and numerous revisions and compromises were made to arrive at what we hope is a well balanced document. Nevertheless, the reader should know that Chapters 2-4 were originally drafted by G.L. Kulcinski; Sections A, C, E, and F of the 5th Chapter by R. Bilder; Sections 5B and 5D by E. Cameron; Section 6A by R. Bilder and the rest of Chapter 6 by H.H. Schmitt; Section 7A by R. Bilder and E. Cameron; Section 7B by R. Bilder, and Section 7C by H.H. Schmitt. Chapter 8 was originally contributed by R. Bilder with significant input from the other three authors and all participants collaborated on the Conclusions (Chapter 9), Recommendations (Chapter 10) and, of course, the Executive Summary.

It was not the task of this study to devise a complete legal model for lunar development. Fortunately, the INTERnational LUNar Enterprise (INTERLUNE) concept, as one possible approach, does exist in enough detail for scholarly analysis. Even though we refer to that concept frequently in the paper, we caution the reader that INTERLUNE is only an example. An endorsement of the INTERLUNE concept by all four authors would require refinement of the model.

We have not been exhaustive in the referencing of previous work quoted in this document, but we have quoted some general references for the readers' benefit. Unlike a strictly technical paper, the conclusions of this work cannot be boiled down to a few numbers or formulas. Instead, we have tried to develop concepts that could be used as the basis for a future, more in-depth study. The reader should view the results of this work in the changing light of technical and political environments.

PRELIMINARY OUTLINE OF
LEGAL REGIMES FOR THE MINING OF HELIUM-3 FROM THE MOON

I. EXECUTIVE SUMMARY

The need for vastly increased amounts of energy in the 21st century to feed, warm, cool, and protect the future 8 to 10 billion citizens of the Earth is not debatable. On the other hand, the methods by which we will provide that energy are a topic of intense discussion today. Approximately 90% of the world's current primary energy supply comes from fossil fuels, and the next largest source is fission energy. The finite and localized nature of fossil fuel resources, in addition to the severe degradation of the environment through the use of our present energy sources, will certainly drive us to other forms of energy in the 21st century.

One form of energy which can provide for centuries of world energy needs as well as alleviate the damage being done to our biosphere is thermonuclear fusion. In particular, the use of the deuterium (D) and helium-3 (He3) fuel cycle is environmentally, technically, and economically attractive enough to warrant a major evaluation of the commercialization of that technology. We know enough today about the D-He3 fusion fuel cycle to predict that if brought to a commercial product, it could have a major worldwide impact by the mid-21st century. Small changes in our existing fusion program and some modest changes in our planned fusion research efforts in the 1990's could bring this fuel cycle to the threshold of commercialization shortly after the turn of the century.

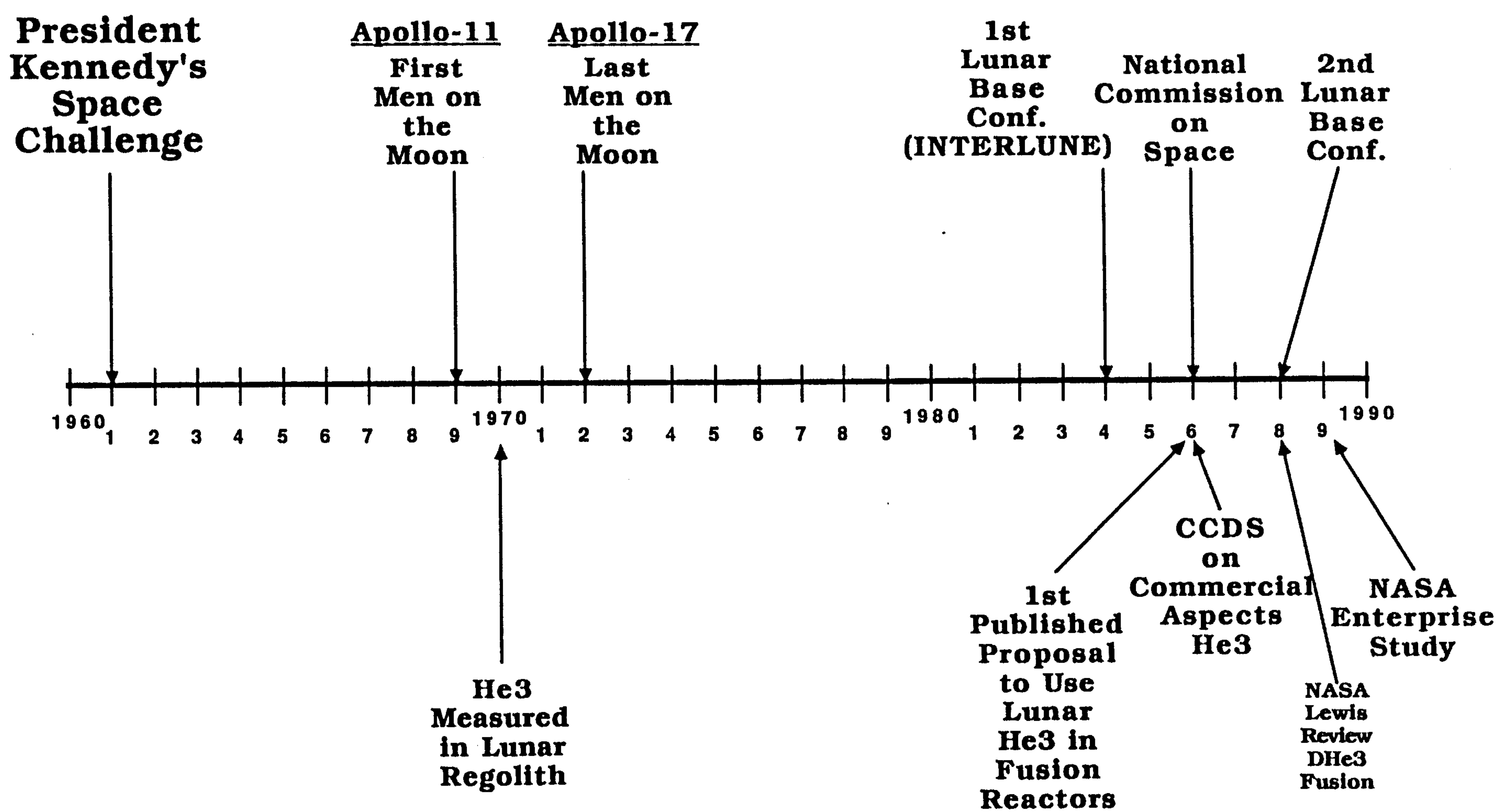
One major barrier to the beneficial use of this fuel cycle has been that there are no large identifiable sources of He3 on Earth which could be obtained economically. Fortunately, astronauts from the Apollo program discovered a large source of He3 on the surface of the Moon in 1970. Recent assessments of that resource base show that it could be as large as 1 million metric tonnes (which is equivalent in energy content to 10 times all the economically recoverable coal, oil and natural gas on the Earth). Furthermore, recent studies sponsored by NASA suggest that the He3 can be extracted and transported to Earth with existing technology at an attractive economic profit (see Figure 1 for a brief chronology of the important events related to the use of lunar He3). Such analyses show that the He3 is worth at least a billion dollars per tonne and, as such, would be competitive with oil at $7 per barrel. This is the first time in history that we have looked to the Moon as a possible solution to our future energy problems and to alleviate pollution here on Earth.

The feasibility of controlling D-He3 plasmas and the feasibility of extracting and transporting the He3 to the Earth has been supported by the results of a recent NASA-Lewis sponsored workshop in Cleveland. Given this one then may ask "under what legal regime could such a major undertaking be accomplished and what should the U.S. be doing now to insure that if we choose to pursue this energy form in the 21st century, we will be able to do so without severely disrupting international order?"

This report examines the above question from the standpoint of existing precedents, laws and treaties. It also puts forth some suggestions as to possible routes which might be taken by the U.S. to insure our beneficial participation in commercial ventures involving He3 resource procurement and the use of the gaseous by-products (H_2, H_2O, N_2, CO, CO_2, CH_4, etc).

Figure 1

Important Events Related to the Use of Lunar He-3



The major precedents which are reviewed include terrestrial mining law, the Law of the Sea Convention, the Antarctic Treaty system, the Outer Space Treaty, the Moon Agreement, INTELSAT, and the Space Station Agreement. Many lessons can be learned from these international endeavors, some positive and some negative. For one thing, it seems clear that western industrialized nations and private commercial enterprises will only commit resources to a He3 resource development program under a legal and economic regime which permits those engaged in such activities a major voice in managing the regime, as well as security of and a fair return on their investments. Thus, arrangements which appear inconsistent with free enterprise principles or which provide control by less-committed nations on a "one nation - one vote" principle (as in the 1982 Law of the Sea Treaty Seabed resources provisions) will probably be unsuccessful in stimulating resource development. More successful arrangements such as INTELSAT and INMARSAT have proved durable over time and have resulted in significant financial benefits to those nations willing to invest resources in projects which are clearly long range and international in nature.

Three possibilities for U.S. action are explored in the full report. First, the U.S. could work through the existing Moon Agreement by negotiating ahead of time, under Article 11, a specific political and financial structure more in tune with U.S. goals. This could be followed by simultaneous ratification of the Moon Agreement and the restructuring of the present provisions of the Moon Agreement. The advantage of this approach is that it would bring together governments into an international organization to work for stability, and a clearly defined legal basis to develop lunar resources could be established.

Second, the U.S. could choose to "go it alone." This could be done in an environmentally acceptable fashion and, by voluntarily sharing a portion of the benefits with developing countries, it could avoid complications over the strict legal interpretation of rights and responsibilities associated with resource development on the Moon.

A third and intermediate approach would be to form an international entity patterned after INTELSAT but slightly modified to incorporate the unique features of He3 mining. A specific proposal for such an organization has been made previously and it is called INTERLUNE (short for the Inter-national Lunar Enterprise). The INTERLUNE proposal is nondiscriminatory in that any nation of the world could join INTERLUNE and its financial return and operational control would be proportional to its investment (see Figure 2). This would avoid the pitfalls of the Law of the Sea Convention. It would also avoid the political and financial risk of "going it alone" by involving those nations of the world willing to contribute resources and expertise to the project.

While no one solution is recommended in this study, the INTERLUNE approach has many interesting features and it is strongly recommended that NASA take a much more in-depth look into the advantages and disadvantages of such a concept, particularly in contrast to the first possibility discussed above. It is not too soon to begin thinking about specific legal and financial frameworks for the following reasons:

INTERLUNE ORGANIZATION CHART

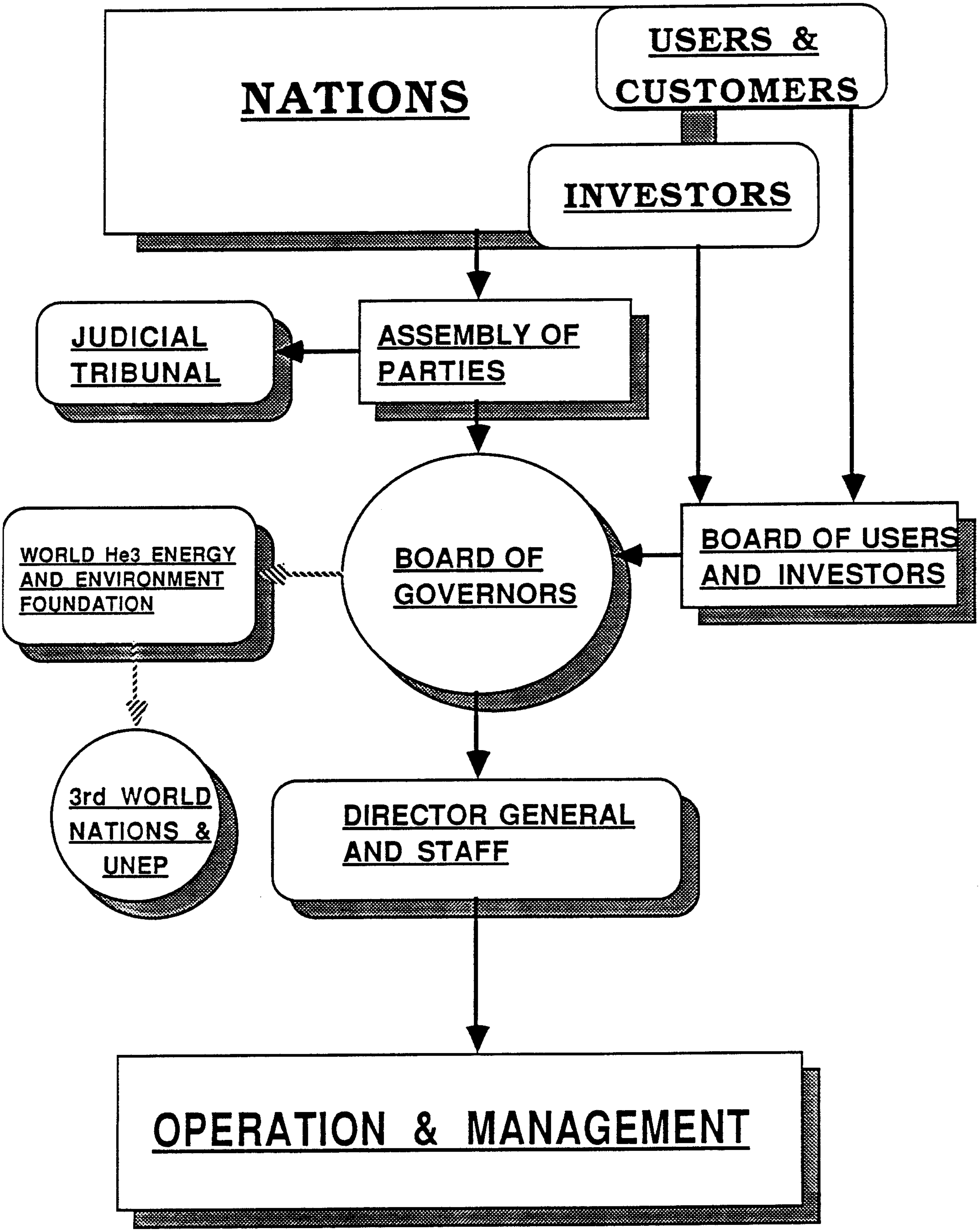


Figure 2. Schematic of the management structure and relationship of the INTERLUNE concept to private citizens and sovereign governments of the Earth.

a) The technology of fusion is advancing rapidly with improvements in plasma conditions of a factor of 10,000 over the past 20 years.
b) The international fusion community (U.S., U.S.S.R., Japan, and European Community) is designing a 1000 Megawatt fusion test facility to operate around the year 2000.
c) The U.S. may be on the verge of returning to the Moon, for other reasons, possibly by the year 2005.

The synergism between the space and energy programs has not been examined in detail before now, but recent events make it imperative that such analyses be done in the next year or two. Individual decisions made in this time period without a proper analysis of the use of He3 may preclude the benefit of this new energy source in the 21st century. Several recommendations are made as to the near term actions that are needed, and these are summarized in Figure 3 for the fusion, space, and financial communities. It is possible that the questions of a safe, clean, and economical energy supply in the 21st century could hinge on our ability to fashion workable organizations to use lunar helium-3.

A complete list of the conclusions and recommendations arrived at in this study is included here, but the reader is strongly encouraged to read the full report for documentation of the steps by which we arrived at such statements.

<u>Conclusions</u>

(1) The deuterium-He3 fuel cycle offers significant safety and environmental benefits as an alternative source of electricity in the 21st Century when compared to the use of coal or uranium.

(2) Given the current rate of research and development in plasma physics and fusion reactor design, it is possible that the first safe and efficient commercial power reactors utilizing He3 could be operated as early as the year 2015.

(3) The D-He3 fuel cycle appears to be economically competitive with other early 21st Century fuel cycles.

(4) It has been scientifically established that vast amounts of He3--sufficient to provide energy for humanity for at least 1000 years--are available on the surface of the Moon and can be extracted and transported to Earth utilizing reasonable extensions of existing technology.

(5) He3 is readily extractable from lunar regoliths by methods analogous to those used in surface mining on earth, using temperatures readily attainable on the Moon and by using known methods of separating He3 from He4 and other gases. Those gases, hydrogen and nitrogen in particular, would be valuable by-products for life support on the Moon and Mars, and for space transportation.

(6) The process of exploitation of lunar He3 is likely to have little detrimental effect on the lunar environment or other uses of the Moon, and will produce by-products (e.g. H_2, H_2O, N_2, CO_2, CO, CH_4, etc.) of great usefulness and importance for the establishment and maintenance of a lunar base or bases on other planets.

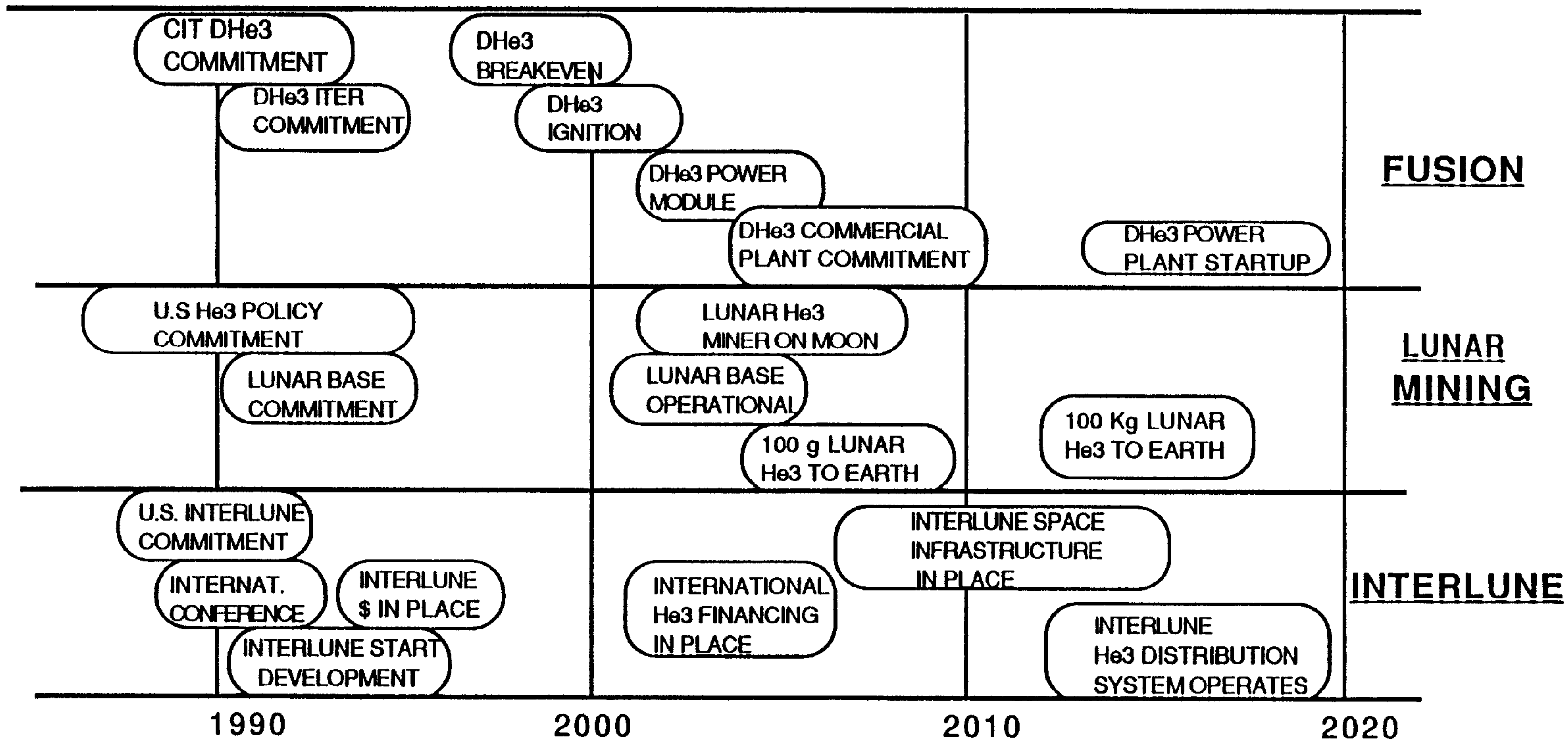


Figure 3. Approximate schedule of major events required to meet a D-He3 power plant start-up in 2015.

(7) An integrated earth-lunar He3 mining and power production system will require a large, complex, and carefully coordinated effort over at least a twenty-five to thirty-year period; private enterprise could play a key role in this development.

(8) Existing space law and other international arrangements suggest that an acceptable basis can be found for cooperative international production of lunar He3. These precedents include various types of national mining laws; the Antarctic system experience; the Moon Agreement; and the INTELSAT, INMARSAT and Space Station Agreements.

(9) Government and, even more so, private investment in the development of a He3 mining and energy system will be difficult in the absence of a stable and predictable legal regime that could provide a reasonable assurance that any such effort and investment will be rewarded. A legal regime must be established which will permit nations or private enterprises to mine and process He3 (and other gaseous by-products) on the Moon, to acquire property rights in the materials and processes, to transport products to earth, to utilize them for the production of energy at a profit, and to retain at least a sufficient share of such profits to warrant the effort, investment, and risk involved.

(10) It is in the U.S. national interest, in the near future, to establish an acceptable lunar resource regime, or at least a commitment to the type of regime acceptable now to the U.S. This needs to be done now instead of waiting for future developments to spur on other nations that may then be in a stronger position than the U.S. vis a vis space capabilities.

(11) A lunar resource development regime acceptable to the U.S. should meet certain criteria, including the following: it must

(a) permit the U.S. and private U.S. enterprises to effectively conduct lunar mining activities, acquiring property rights in the product, transporting it to Earth, and retaining reasonable profits from such activities;
(b) be consistent with international law;
(c) encourage international cooperation; and
(d) recognize and be sensitive to other broader international community and public concerns, particularly with respect to the environmental concerns.

(12) The Law of the Sea Treaty and Antarctic Mineral Resources Convention represent two different approaches to devising an international framework for resource development. The first is an attempt to involve all nations equally in resource development under the guidance of the United Nations. It has been strongly opposed by the U.S. and other western industrial nations. The second calls for control by only those nations actively involved in Antarctic exploration and environmental research. It appears to be on the verge of ratification. Lessons for the development of He3 can be learned from both of these international proposals.

(13) The Outer Space Treaty and the Moon Agreement state general principles that currently guide international thinking on the exploration of space and the Moon, and obligations of participating states. The Moon Agreement calls for establishment of an international regime for the Moon, but does not spell out the structure of such a regime at this time.

(14) The INTERLUNE concept describes an attractive legal structure for the use of resources from the Moon, and it includes policy-making, governing, and executive bodies. Control would be vested in states currently active or soon to be active in lunar exploration, but allowance is made for future participation by other states as they develop the capacity for and commitment to lunar development.

(15) The long economic, practical, and legal experience of the U.S. in encouraging private sector involvement in mineral resource development, along with the potential environmental urgency of developing early 21st Century energy alternatives, suggests that the U.S. could and may have to consider unilateral development of the D-He3 fuel cycle and lunar He3 production if other nations choose not to participate.

(16) While the U.S. could proceed unilaterally, there are a number of arguments in favor of establishment, by the U.S., of an international lunar resource regime on a multilateral basis. In particular, an internationally-supported regime, properly configured, could be more stable and predictable over the long time period involved, reduce the likelihood of disputes, provide the basis for mutually advantageous cooperation, and thus provide a more secure investment climate favorable to long term commitments.

(17) One way the U.S. might proceed toward an international regime is to set up a quasi-public corporation to undertake its development and operational activities, seek agreement on an acceptable lunar resource regime among the "space powers", and then to seek to incorporate this agreement within the framework of the Moon Agreement. This could be done by having the nations agree to such a regime in advance, with an arrangement under which they will then simultaneously ratify the Moon Agreement and call for a conference on Articles 11(5) and 18 to formalize this previously agreed resource regime within the Moon Agreement's own treaty framework. Alternatively, if ratification of the Moon Agreement proved politically unachievable, an independent agreement on an acceptable lunar resource regime might be concluded, outside the framework of the Moon Agreement, perhaps incorporating and consistent with the general tenor and provisions of the Moon Agreement apart from Article 11.

(18) The difficulties experienced by consensus and "one nation-one vote" organizations in the management of international enterprises, and the success of user interest organizations like INTELSAT, strongly suggests that the INTELSAT approach might be preferable in the management of international fusion and lunar resource development.

(19) Of proposals thus far offered for the Moon, the INTERLUNE concept is the most advanced in its development of a legal structure and is consistent with U.S. commitments and policies with regard to space. It would

ensure a role for both private and national enterprises, protect the consumer, provide for environmental protection, and provide for eventual participation by all states in proportion to their commitment and contributions to lunar development.

(20) The nation must make an unequivocal commitment, backed by sufficient human and financial resources, to be the dominant player in space and in the development of a lunar helium-3 energy system for the Earth. This commitment is necessary if the U.S. is to have either a national or international option for a future in space and, potentially, for the future of the Earth's environment. With such a commitment, the pressure on the rest of the world to join with us in a workable international management organization will be enormous. Without such a commitment, we may not be invited to play a serious role in a Soviet, European, or Asian-dominated effort which might arise.

Recommendations

(1) NASA, along with other federal agencies (Dept. of State, Dept. of Energy, Dept. of Commerce, etc.), industry and universities should integrate the appropriate aspects of existing international arrangements (e.g., the Moon Treaty, INTELSAT, or the Antarctic Treaty) into a policy framework for the successful development and utilization of lunar volatiles.

(2) In parallel to recommendation (1), NASA should also develop and evaluate an alternative United States "go it alone" strategy for the extraction and use of lunar He3 resources.

(3) NASA should undertake a detailed examination of the proposed INTERLUNE organization as a possible approach to the international management of lunar resources.

(4) The United States, through NASA and in consultation with other qualified governmental agencies, professional societies, and commercial entities, should convene a national workshop to undertake an in-depth examination of:

(a) the type of acceptable lunar resource legal regime which would meet the United States needs,
(b) the optimal strategy for the United States to achieve such a legal regime.

(5) The United States, through NASA and the State Department, should consider the feasibility of achieving an early consensus with other "space powers" on an acceptable legal regime by either collective ratification of the Moon Agreement with simultaneous inclusion of the preferred legal regime into Articles 11(5) and 18, or by means completely independent of that Agreement.

(6) NASA should undertake, in cooperation with other federal agencies (DOE, NOAA, EPA, etc.), a net assessment of the total environmental effects associated with the production of electrical energy through the D-He3 fusion fuel cycle. This assessment should include;

(a) terrestrial effects such as reduced thermal, air, and radioactive pollution,
(b) increased safety aspects of terrestrial D-He3 fusion plants,
(c) environmental impacts on the lunar environment such as surface alterations, vacuum degradation, waste products, etc.

It is important that NASA demonstrate, from the very beginning of lunar resource utilization, its openness to the receipt of outside views on environmental matters and a willingness to accommodate valid public concerns.

(7) NASA should encourage the Dept. of Energy to:

(a) Pursue D-He3 research in present fusion facilities such as TFTR at Princeton.
(b) Include D-He3 research capabilities in the proposed Compact Ignition Torus (CIT) and the International Thermonuclear Experimental Reactor (ITER).
(c) Increase emphasis on the conceptual design of D-He3 commercial power plants.

(8) NASA should undertake (along with DOE, Dept. of Interior, Dept. of Commerce, industry and the university community) a detailed assessment of the economic competitiveness associated with the D-He3 fuel cycle. Such a study should establish the allowable variations in key economic parameters, including environmental credits in the 21st century.

II. INTRODUCTION

II.A Statement of the Problem

The twin spectres of dwindling fossil energy resources and increasing environmental threats from the burning of those fuels, as well as the question of the disposal of energy-related wastes, strongly supports the search for new, abundant, safe, and clean energy forms for the 21st century. The recent recognition [1] that such a fuel exists on the surface of the Moon in the form of a rare isotope of helium (He3) has both improved our expectations for a stable and prosperous 21st century and stimulated efforts to determine if and how such a form of energy could be developed in concert with the needs and desires of Americans and, if possible, all citizens of the Earth.

Specifically, how can we develop a source of energy in space which still requires a significant level of financial investment on Earth to release that energy? What are the incentives, financial, environmental, and political, to counter the risk involved in returning to the Moon for this valuable fuel?

Ultimately, it is necessary to determine the managerial and legal frameworks (i.e., the regimes) that could be constructed so that the benefits from this fuel can be enjoyed by all. At the same time, these regimes* should protect the incentives that will encourage the more adventurous developers from the United States to take the risks necessary to provide large amounts of helium-3 at a low cost. This study will analyze and discuss options that the U.S. might consider for these regimes.

II.B Importance of the Problem

During the 20th century, the availability of large amounts of energy has become a critical problem for humankind. Since the turn of the century, humankind has consumed energy on an ever-increasing scale. The standard of living, political stability, and general health and welfare of the 5 billion people now living on Earth are intrinsically tied to a free flow of this energy. Even larger supplies of energy will be essential for survival and improved quality of life in the 21st century. What will be the source or sources of this energy? Most of the energy produced during the past 100 years has come from the fossil fuels. Unfortunately the consequences are all too apparent in smog-filled cities, dying forests, dead lakes, and concern about permanent damage to the Earth's biosphere. It has become evident, especially since the 1970's, that an alternative source of energy must be found, one that is safe, steady, reliable, and environmentally benign. Helium-3 from the Moon offers such an alternative, but if it is to become available, it is essential that agreement be reached on a legal framework within which the helium resources of the Moon can be tapped and that all nations will be able to

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**The word "regime" is used throughout this report in the context of "a mode or system of government, administration, or management". The term "regime" implies the existence of some body of national or international rules concerned with the development and utilization of lunar resources. However, it does not suggest anything about the specific content of such rules nor does it imply the establishment of any specific governing national or international institutions (e.g. the UN).*

participate in the benefits of such a fuel. The discussion of the conceptual nature of that framework should be high on our list of priorities if we wish to have a smooth transition to the generation of energy from helium-3 in the early 21st century.

II.C Approach to the Problem

The organization of this study is in four distinct parts;

1. A background on importance of He3 and the technology associated with the procurement of He3 (Chapters III and IV).
2. A discussion of precedents from terrestrial resource development experience and current space laws and treaties (Chapter V).
3. The unique aspects of He3 as a resource and previous work related to lunar resources (Chapter VI).
4. Proposals for possible U.S. positions and suggestions of how to achieve those positions (Chapters VII and VIII).

These broad discussions are followed with the conclusions of this study (Chapter IX) and recommendations for future work (Chapter X).

It is certainly recognized that this report is only a beginning on the road to developing a political and legal framework for commercialization of He3 fuel. The ultimate solution will evolve from future technological, political, and financial constraints on our society.

Reference for Chapter II

[1] L.J. Wittenberg, J.F. Santarius, and G.L. Kulcinski, Fusion Technology, 10, 167 (1986).

III. IMPORTANCE OF HELIUM-3 FOR THE FUTURE

III.A Historical Perspective

Scientists first proposed the use of thermonuclear energy for civilian applications in the 1950's. This work closely followed on the heels of the Hydrogen Bomb, and it was felt that commercial fusion energy would take only a few decades to perfect. Unfortunately, the difficulty of controlling plasmas (collections of charged particles and electrons) at temperatures 10 times hotter than the center of the sun proved to be much more difficult than originally anticipated. Most of the 1960's was spent developing the field of plasma physics and laying the ground work for a theoretical understanding of plasmas. By the end of the 1960's, and with unprecedented cooperation between U.S. and Soviet scientists, it became apparent that once the plasma physics problems were solved, significant technological progress was also needed to develop a safe and clean power source. Thus, in the 1970's, a dual approach to the problem was pursued; 1) several large plasma physics facilities were constructed to test the theories developed in the 1960's and 2) engineering analyses of power plant designs were initiated to ascertain the technological, economic, safety, and social implications of this new form of energy. Both of these lines of research have been continued in the 1980's with a major milestone of energy breakeven (i.e., the point at which as much energy is emitted from the plasma as it takes to keep it hot) within our grasp as we move into the 1990's. The current plan is to construct several large reactor-like facilities in the 1990's which will produce power in the 500 to 1000 megawatt regime and to use these facilities to test materials and power conversion schemes that might be used in the 21st century.

The worldwide fusion effort is now roughly equal in Europe, Japan, the United States and the USSR. In the early 1980's, approximately 2 B$ per year was being spent on fusion research with the U.S. in the lead of that effort. Today, the total effort is slightly less but it is clear that the European program has taken the lead from the U.S. and that a strong challenge for 2nd is being made by the Japanese. Altogether over 20 B$ in then current dollars has been spent on fusion research since the early 1950's.

Further descriptions of the fusion process can be found in the references at the end of this chapter [1,2], and only those aspects of this fuel cycle important for this paper will be repeated here. The reader is strongly urged to consult the references for more information on fusion.

III.B Relevant Plasma Physics Principles of Thermonuclear Research

Since the early days of the civilian thermonuclear fusion program, scientists had always envisioned that fusing a deuterium (D) and tritium (T) atom at very high temperatures (see equation 1) would prove to be the most favorable for the production of electricity.

$$D + T \rightarrow He4 + neutron \qquad (1)$$

Energy released, Q = 17.6 Million Electron Volts (MeV)

There were several reasons why this choice was made, ranging from the fact that the DT cycle ignites at the lowest energy (see Figure 1) to the experience gained from the thermonuclear weapon program in breeding and handling tritium. Two other reactions, listed below, were also briefly considered.

$$D + D \xrightarrow{50\%} T + H \qquad Q = 4.0 \text{ MeV}$$
$$D + D \xrightarrow{50\%} n + He3 \qquad Q = 3.3 \text{ MeV} \qquad (2)$$

$$D + He3 \rightarrow He4 + H \qquad Q = 18.4 \text{ MeV} \qquad (3)$$

Neither of these reactions has received much attention since the 1950's, because they both require higher temperature (see Figure 1) to ignite and because, there was no significant resource of He3 available on Earth.

Several things have changed since those early days of fusion research, and two of these will be addressed in this chapter. First we will address the changing situation in fusion physics, and second we will address the renewed interest in the technological and environmental advantages of the D-He3 cycle. The question of the He3 fuel supply will be addressed in Chapter IV.

III.C State of Plasma Physics as it Pertains to the D-He3 Cycle

Simply stated, the objective in magnetic fusion research is to heat the confined plasma fuel to sufficiently high temperatures (T) at high enough densities (n) and for long enough times (τ) to cause substantial fusion of atoms to take place. Mathematically stated for a reactor using the DT cycle, this can be given as;

$$n\tau \geq 2 \times 10^{14} \text{ seconds per cm}^3 \quad @\ T \geq 20 \text{ keV (200 million °C)} \qquad (4)$$

Some perspective on the rate of progress in producing these conditions is given in Figure 2a where the $n\tau T$ values achieved are plotted with respect to when they were first attained and Figure 2b which shows the progress toward energy breakeven. The $n\tau T$ product has been increasing at the phenomenal rate of a factor of 100 every 10 years. In fact in one parameter, namely the temperature T, scientists have actually produced 30 keV ions in TFTR plasmas at the Princeton Plasma Physics Laboratory (PPPL). This is 50% higher than needed for a DT reactor and only a factor of 2 lower than needed for a D-He3 reactor. The appropriate n,τ, and T values for a D-He3 reactor are

$$n\tau \geq 4 \times 10^{15} \text{ seconds per cm}^3 \qquad (5)$$

$$\text{at } T \cong 60 \text{ keV (600 million °C)}$$

A detailed physics analysis shows that the Compact Ignition Torus (CIT) at PPPL could achieve the temperatures above in the mid to late 1990's.

While it is necessary to reach a $n\tau T$ product of ~ 100 for breakeven in DT and a value of 400 for DT reactor operations (Figure 2), it is necessary to achieve a $n\tau T$ product of 24,000 for the D-He3 reactor. Recent analyses show

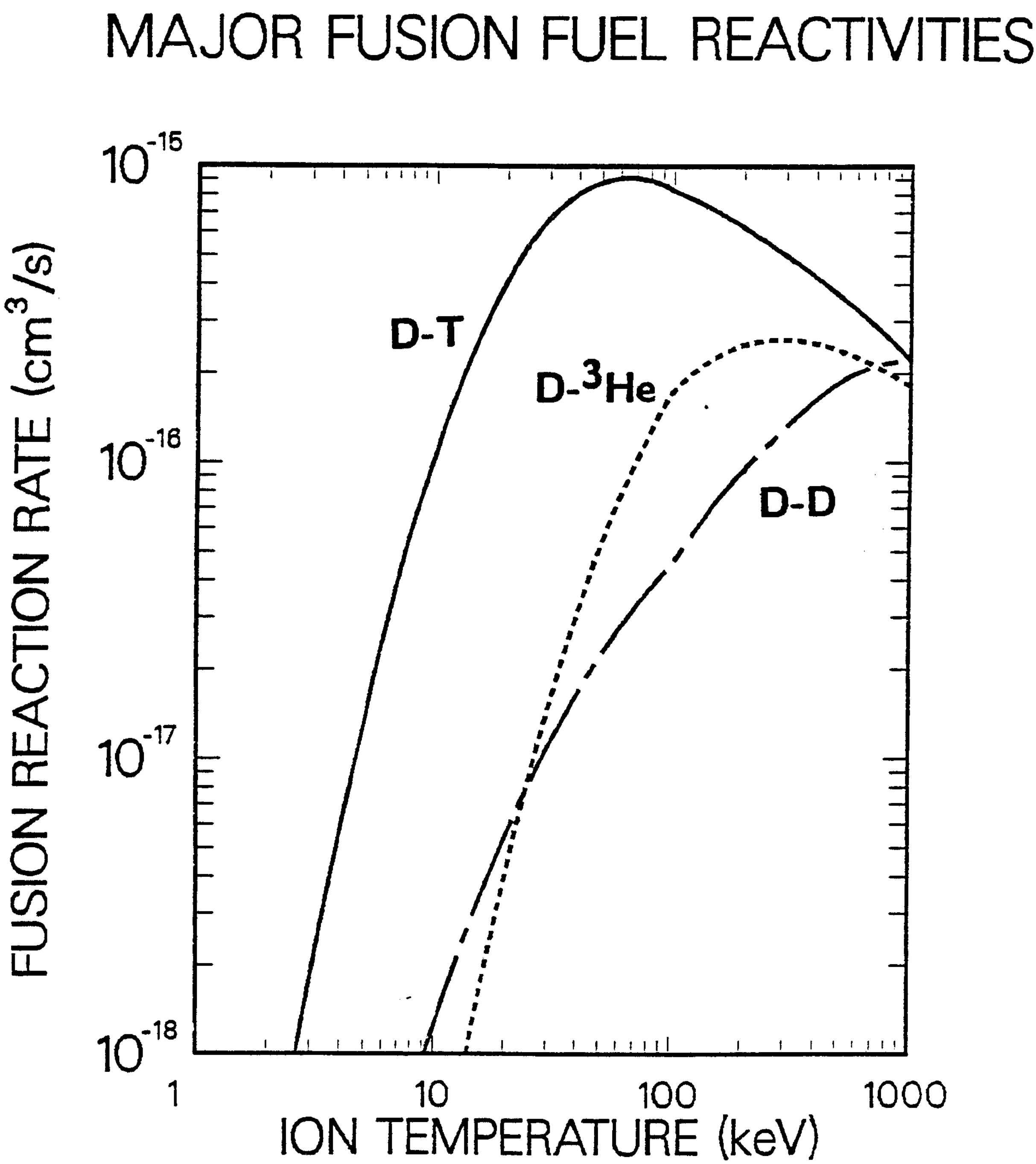

Figure 1. Major Fusion Fuel Reactivities

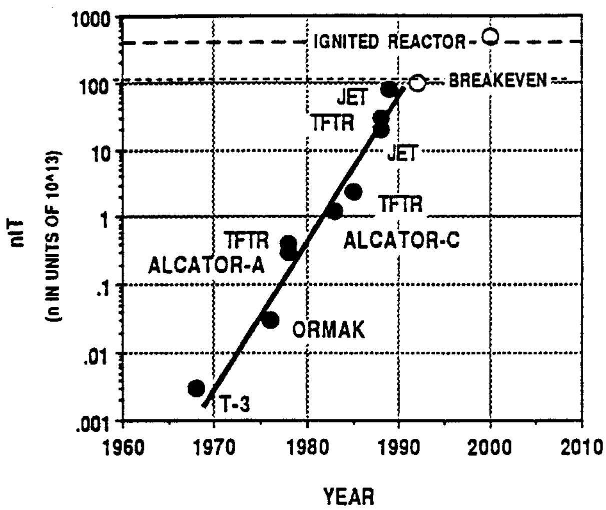

Figure 2A. Steady progress in the 3 major physics parameters for DT fusion.

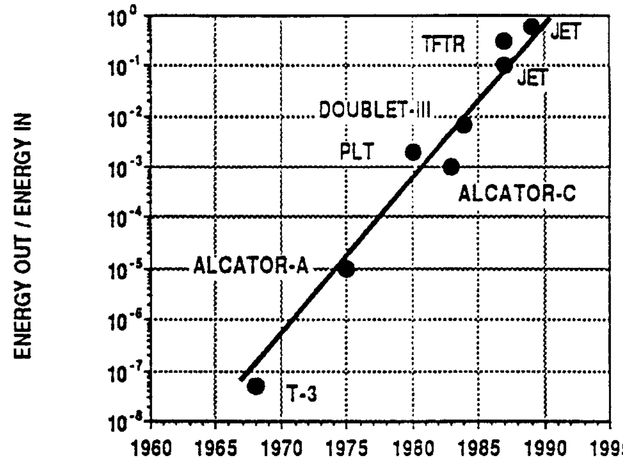

Figure 2B. The progress toward energy breakeven conditions has shown an increase of over 1000 every 10 years for the past 20 years.

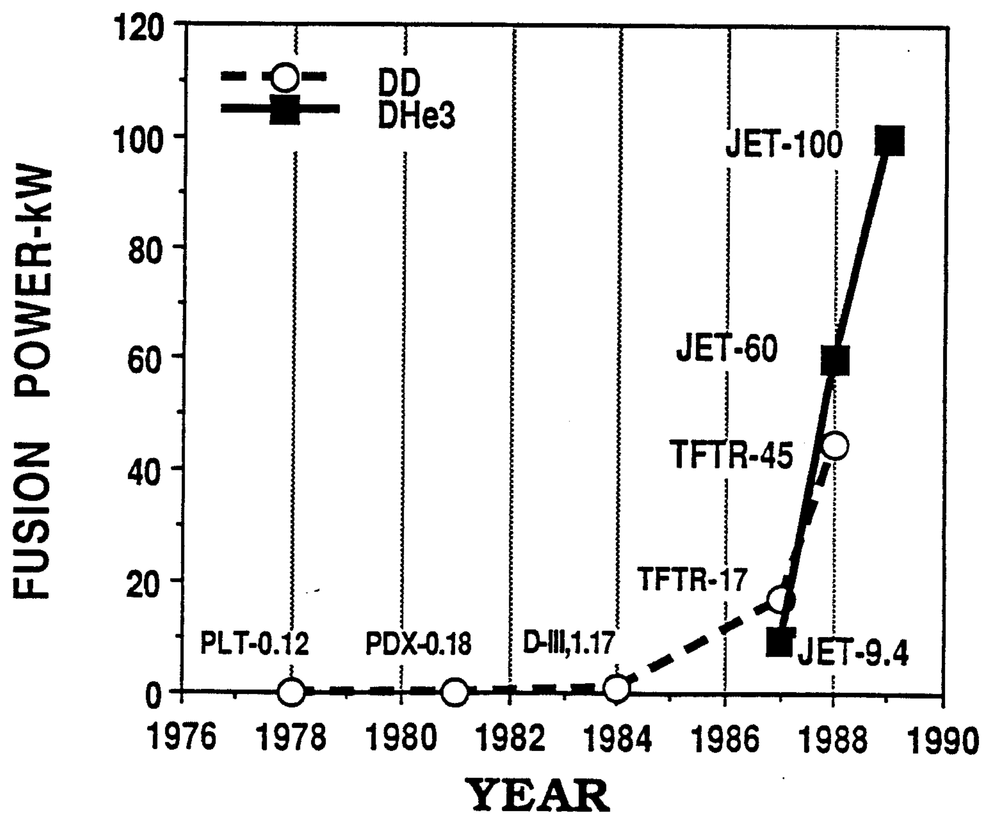

Figure 3. Actual release of thermonuclear energy in the laboratory by the DD and D-He3 reactions from the PLT, PDX and TFTR devices at Princeton, the D-III device at General Atomic, and the JET device in Culham, England.

that such values could be achieved by small modifications of the Next European Torus (NET) or the International Thermonuclear Experimental Reactor (ITER) currently being designed for operations around the year 2000. In other words, despite the factor of 60 required in $n\tau T$ values for a working D-He3 power plant over a DT system, several possibilities to achieve those values are available.

The surprising historical point of the previous discussion is that only a few short years ago, most scientists would have believed it impossible to produce the necessary D-He3 reaction conditions before the year 2020 or even later. However, scientists at JET have recently produced 100 kW of thermonuclear power with the D-He3 cycle (see Figure 3). The possibility that significant power could be produced with He3 before the year 2000 has opened up a whole new class of studies within the past 2 years and caused a complete reassessment of our long-range goals in fusion research.

III.D <u>Technological Benefits of the D-He3 Fuel Cycle</u>

One of the key features of the D-He3 reaction in Equation 2 is that both the fuel and the reaction products (protons and He4) are <u>not</u> radioactive. However, some of the deuterium ions do react with each other producing a small amount of neutrons and tritium. When the cross section and fuel mixtures are included, one can calculate how much of the average energy release is in the form of neutrons (see Figure 4). Whereas the DT cycle releases 80% of its energy in neutrons regardless of the plasma temperature (and the DD cycle releases ~ 50% in neutrons) one can see that operation at ~ 60 keV with a 3:1 ratio of He3/D, can result in release of as little as 1% of the energy in neutrons in a D-He3 plasma.

Why is this important? The radioactivity and radiation damage of reactor components is directly proportional to the number of neutrons produced. Since the energy released per reaction from DT and D-He3 is roughly the same, the problem associated with neutrons can therefore be reduced by almost 2 orders of magnitude (i.e., a factor of 80).

The main technological advantages resulting from these characteristics of the D-He3 fuel cycle, when compared to the DT cycle, are summarized as follows:

a) Increased electrical conversion efficiency.
b) Reduced radiation damage.
c) Reduced radioactive waste.
d) Increased level of safety in the event of an accident.
e) Lower cost of electricity.
f) Shorter time to commercialization.

Only a very brief comment on each of these features will be made here and the reader is referred to several recent publications by the authors for a more in-depth analysis.

III.D.1 <u>Efficiency</u>

It is obvious that if only ~ 1% of the energy is released in neutrons, then the other ~ 99% is released as charged particles or photons. In linear

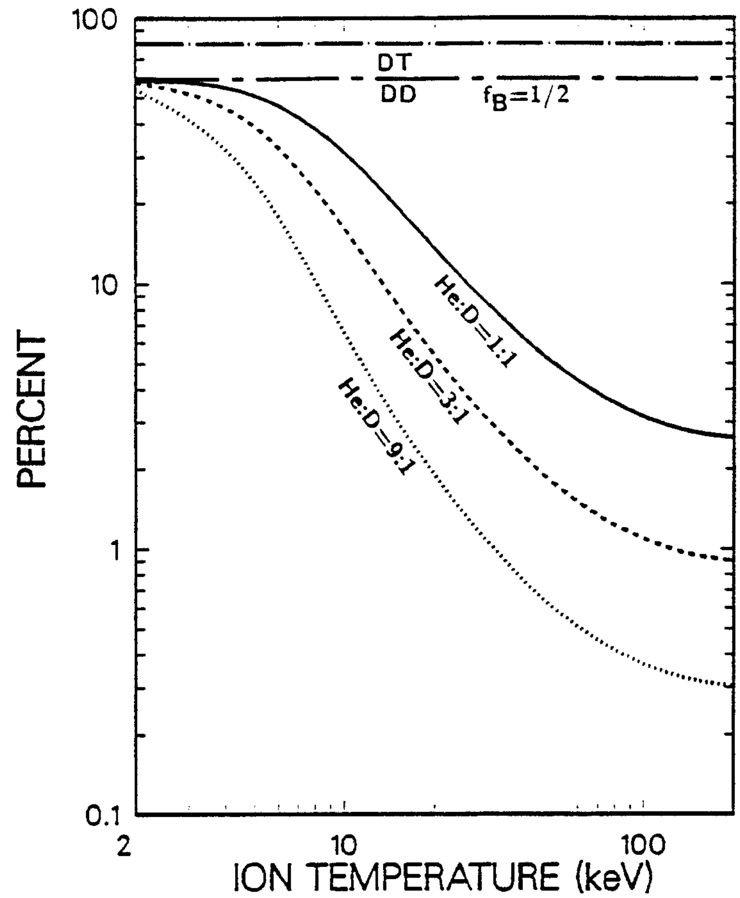

Figure 4. The percent of thermonuclear energy released in the form of neutrons by the DT, DD, and D-He3 fuel cycles. Note the variation of He3 to D ratio.

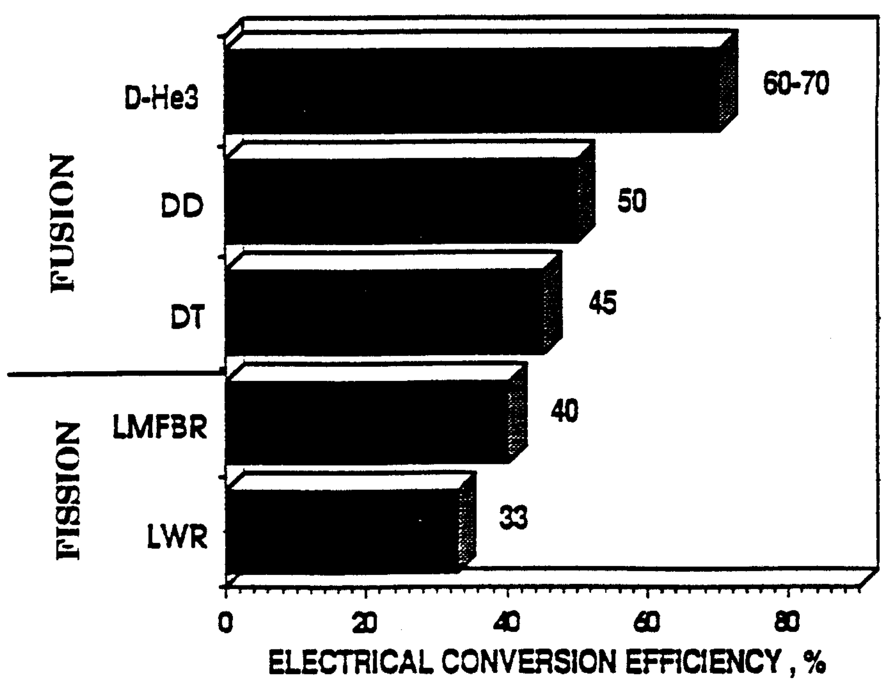

Figure 5. A comparison of overall conversion efficiencies of nuclear energy to electricity. The use of direct electrostatic or electromagnetic energy conversion schemes greatly enhances the performance of fusion devices.

magnetic fusion devices where most of the energy leaks from the reactor in the form of highly energetic charged particles, one can convert their kinetic energy directly to electricity via electrostatic converters at ≥ 80%. This means that overall plant efficiencies of 60 to 70% are achievable. In toroidal magnetic devices, one can convert the synchrotron radiation emanating from the electrons (frequency ~ 3000 gigahertz) directly to electricity at roughly the same efficiencies through the use of rectenna. Depending on how the other forms of energy emitted from the plasma are utilized, the efficiency in toroidal devices may then be in the 40-60% range.

A comparison of the maximum conversion efficiencies that might be achieved by fission or fusion devices is shown in Figure 5. The important point to note is that fusion devices may increase the efficiency of fuel usage by a factor of 50 to 100% compared to fossil fuels or fission reactors. Such considerations are very important for thermal pollution in a terrestrial setting, but they are, in fact, critical to power plants that may operate in space. The rejection of heat in space is very, very costly.

III.D.2 Radiation Damage

When high energy neutrons, such as the 14 MeV neutrons emitted from the DT reactions, run into structural reactor components, they can greatly reduce the mechanical performance of those components and induce significant long-lived radioactivity. With our present state of knowledge, it will be difficult to operate a fusion reactor for more than a few years before the metallic components become so brittle that they will have to be replaced. This requires shutting the reactor down, handling highly radioactive components, exposing workers to ionizing radiation, and generating large volumes of radioactive waste. Our best estimates at this time are that 2 to 3 reactor-years are about the limit for present day materials. Since reactors should operate for 30 or more years, such changeouts will occur 10 or more times during the lifetime of a typical DT fusion plant.

On the other hand, if we can reduce the neutron fraction to ~ 1% of the energy released in the D-He3 cycle, then the metallic components will last ~ 80 times longer than in a DT reactor. Such an extension is enough to completely obviate the necessity for component change due to neutron damage. This longer life will have profound economic and environmental benefits in a society based on the use of fusion energy.

III.D.3 Reduced Radioactivity

Because of the much smaller number of neutrons, the induced radioactivity in the reactor walls will also be reduced by a factor of ~ 80. In today's DT fusion reactor designs, special materials have to be developed to avoid generating large amounts of high level wastes that must be placed in deep underground repositories. Conventional steels for example, would become so radioactive that 10's of tonnes per reactor-year could only be disposed of in one of the national deep repositories scheduled for operation near the turn of the century. On the other hand, these same materials would last the full 30 year life of a D-He3 plant and still could be disposed of as low level class C waste buried in near surface disposal sites. If low activation steels are developed, then such alloys, after 30 years of operation could be buried along with medical waste in near-surface sites. Aside from the tremendous savings in cost, one would find that these D-He3 wastes would decay to benign levels in less than 100 years instead of the 1000's of years required for current fission and fusion devices.

III.D.4 Safety

One of the most severe accidents that could occur in a DT fusion plant is the complete loss of coolant along with a complete breach of reactor containment. The afterheat in a DT reactor can be sufficient to release large amounts of tritium and radioisotopes from the reactor structure. At present, it is not known whether we can keep critical components from melting in a commercial DT reactor.

In a D-He3 reactor, two fundamental characteristics prevent such dire consequences. First, the afterheat (which comes directly from the neutron activation products) is so low that in the event of the most severe accident to be imagined, and if no heat leaked from the system (e.g., if the entire reactor was wrapped in a perfect, thermally insulating blanket), the maximum temperature increase in a week would be ~ 500°C (still 1000°C below its melting point). Secondly, the tritium inventory in a D-He3 plant can be as little as 2 grams. The complete release of this tritium in a rain storm could still cause no more exposure to a member of the public living next to the D-He3 reactor than he or she normally receives from cosmic rays or radon gas in a year's time. In other words, there is no possibility of an offsite fatality due to the release of all the volatile tritium radioactivity in a D-He3 fusion power plant and the consequences of such a release would be hard to detect among the populace.

III.D.5 Cost of Electricity

There are features of the D-He3 fuel cycle which strongly suggest that it will provide electricity more cheaply than a DT fusion power plant. These are

a) lower capital cost
b) lower operation and maintenance costs
c) higher efficiency
d) higher availability.

The first point is based on a comparison of two recent D-He3 reactor designs, Ra [3] and Apollo [4] to 17 previous DT reactor designs, most done by the same group with the same costing philosophies. The results of this comparison are shown in Figure 6. The capital cost of the Apollo-L D-He3 system is ~ 20-50% lower than comparable DT plants. The reason for this has to do with the greatly reduced balance of plant costs (i.e., that part of the power plant outside the fusion reactor) associated with conventional steam generators and turbines. It also has to do with the fact that D-He3 plants, which contain such low levels of T_2 and radioactivity, can use conventional construction grade material, thus avoiding the high nuclear-grade material costs associated with fission and probably with DT fusion reactors.

Because of the low radioactivity and because there should be no repair required from neutron damage, the number of plant personnel can be greatly reduced compared to a DT plant. The use of solid state electrical conversion equipment also will require less maintenance personnel.

HISTORICAL CAPITAL COSTS OF COMMERCIAL FUSION REACTOR DESIGNS

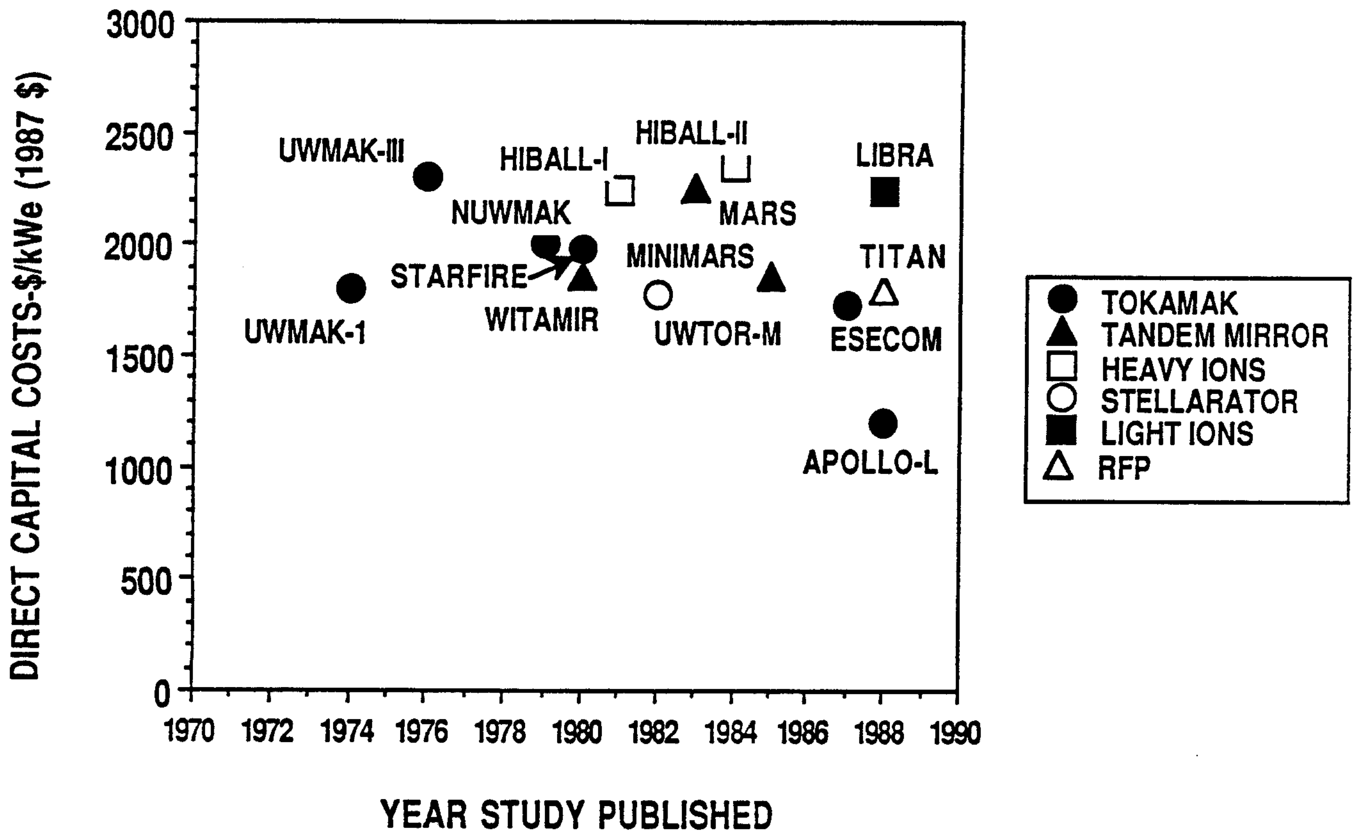

Figure 6. Historical Capital Costs of Commercial Fusion Reactor Designs

The higher electrical efficiency will have a direct effect on the specific cost parameters. For example, the capital cost per kWe will be lower for the same thermal power, and the cost of heat rejection equipment (i.e., cooling towers) will be greatly reduced.

Finally, the ultimate cost of electricity, in mills per kWh, can be reduced if the plant stays on line for a larger fraction of its total lifetime. As stated previously, a DT power plant has to be shut down frequently to change neutron-damaged components. The duration of the down time will be adversely affected by the induced radioactivity and the problems associated with tritium contamination. It is also well known that plants which use a high-pressure steam cycle require, on average, on the order of 10-15% of their total life time to repair steam turbines and heat exchangers. The use of solid state conversion equipment should reduce that number similar to the way solid state TV sets are more reliable than those which used vacuum tubes.

The time from now to commercialization of D-He3 fusion could be shorter than the time to commercialize the DT cycle even if it takes longer to solve the remaining physics problems. The reason for this again lies in the low fraction of neutrons released in the D-He3 cycle and the need to develop a whole new class of metals and alloys to withstand the damage associated with the 14 MeV neutrons from the DT cycle. Conservative estimates of the cost to solve this problem include a materials test facility (1-2 B$ capital plus 10-15 years operating time requiring another 1-2 B$ in operating expenses), and a completely new blanket test facility in a demonstration power plant (3-4 B$ + 10-15 years and ~ 5 B$ operating costs) before one could get to a commercial system. Add to this significant sum the cost of an auxiliary technology program for 20-30 years <u>beyond</u> the solution of the physics problems (another 10-20 $B) and we can see that an additional ~ 30 $B and 30 years could be required to commercialize DT fusion after the DT operation in the ITER class of fusion devices in the year 2005.

On the other hand, if the ITER could be slightly modified (for less than 10% of its present cost) to ignite D-He3, then the same reactor could also be used to generate electricity in a demonstration reactor mode by 2005-2010. Since there is no need for a materials test facility nor for the need of developing breeding blankets, a new D-He3 commercial plant could be operational by the year 2015-2020, a full 15-20 years sooner than possible with the DT cycle.

References for Chapter III

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[3] G.L. Kulcinski, G.A. Emmert, H. Attaya, J.F. Santarius, M.E. Sawan, I.N. Sviatoslavsky, and L.J. Wittenberg, "Commercial Potential of D-He3 Fusion Reactors," Proc. 12th Symp. Fusion Engr., Monterey, CA, IEEE-87CH2507-2, p. 772 (1987).

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IV. AVAILABILITY OF HELIUM-3

IV.A Terrestrial Resources

It was commonly believed in the fusion community that after the questions of plasma physics have been solved, the next single largest barrier to the widespread study of the D-He3 reaction would be the lack of any large identified terrestrial source of helium-3. Studies by the SOAR (Space Orbiting Advanced Reactor) concept at the University of Wisconsin in 1985 identified only small amounts of indigenous He3 on the Earth and a roughly equal-sized source from the decay of tritium ($t_{1/2}$ = 12.3 years) in the U.S. thermonuclear weapons program (see Table 1).

Most of the primordial He3, present at the formation of the Earth, has long since diffused out of the Earth and been lost in outer space. What is left in any retrievable form is contained in the underground natural gas reserves. Table 1 reveals that the total He3 content in the strategic He reserves stored underground amounts to only some 30 kg. If one were to process the entire United States known conventional natural gas reserves, another 200 kg of He3 might be obtained.

Another source of He3 on Earth is from the decay of tritium ($t_{1/2}$ = 12.3 years). When T_2 decays, it produces a He3 atom and a beta particle. Simple calculations of the inventory of T_2 in U.S. thermonuclear weapons shows that if all the He3 were collected, some 300 kg would be available by the year 2000. Presumably about the same amount of He3 would be available from the weapons stockpile of the USSR. The equilibrium production of He3 (assuming no future change in weapons stockpiles) is around 15 kg per year in each country. It may seem strange to rely on a by-product from weapons for a civilian application, but the He3 commercially available today is from just such a process. One can purchase up to 1.38 kg of He3 per year directly from the U.S. government (10,000 liters at STP) all of which comes from T_2 decay. Obviously, considerably more is available, and simple calculations of the tritium production from U.S. facilities at Savannah River indicate that tritium production could be in the 10-20 kg per year range. This would imply an "equilibrium" He3 production rate of ~ 10-20 kg/year minus losses in processing.

One could also get smaller amounts of He3 from the T_2 produced in the heavy water coolants of Canadian CANDU reactors. This could amount to 10 kg of He3 by the year 2000, and He3 will continue to be generated in these plants at a rate of ~ 2 kg per year thereafter.

It should be noted again that 1 kg of He3, when burned with 0.67 kg of D, produces approximately 19 MW-y of energy. This means that by the turn of the century, when there could be several hundred kg's of He3 at our disposal, the potential exists for several thousand MW-y of power production. The equilibrium generation rate from T_2 resources alone could fuel a 300 MWe plant indefinitely if it were run 50% of the time.

Clearly, there is enough He3 to build an Experimental Test Reactor (ETR) (a few hundred MW's running 10-20% of a year) and a demonstration power plant of hundreds of MWe run for many years. This could be done without ever having to leave the earth for fuel. The real problem would come when the first large (GWe) commercial plants could be built around the year 2015.

RESERVES OF He3 THAT COULD BE AVAILABLE IN THE YEAR 2000

SOURCE	CUMULATIVE AMOUNT (kg)	PRODUCTION RATE AFTER YEAR 2000 (kg/y)
PRIMORDIAL-EARTH		
• US HELIUM STORAGE	29	-----
• US NATURAL GAS RESERVES	187	-----
TRITIUM DECAY		
• US NUCLEAR WEAPONS	300	~15
• CANDU REACTORS	10	~2
TOTAL	>500	~17

Note:1 kg of He3 burned with 0.67 kg of deuterium yields 19 MW-y of energy

Table 1. Amounts of He3 That Could Be Available in the Year 2000

IV.B What and Where are the He3 Resources on the Moon?

Wittenberg et al. [1] showed in September 1986 how the He3, first discovered on the Moon by the Apollo-11 mission, could be utilized in a fusion economy. Since that time, work at the University of Wisconsin has elaborated on the original idea. A few highlights will be summarized here.

The origin of lunar He3 is from the solar wind (i.e., the charged particles leaking from the sun and "blowing" on the rest of the bodies in the solar system). Using data which showed that the solar wind contains ~ 4% helium atoms and that the He3/He4 ratio is ~ 480 appm, it was calculated that the surface of the Moon was bombarded with over 250 million metric tonnes in 4 billion years. Furthermore, because the energy of the solar wind is low (~ 3 keV for the He3 ions), the ions did not penetrate very far (< 0.1 micron) into the surface of the regolith particles (lunar soil). The fact that the surface of the Moon is periodically stirred, as the result of frequent meteorite impacts, results in the helium being trapped in soil particles to depths of several meters.

Analysis of Apollo and Luna regolith samples revealed that the total helium content in the Moon minerals ranges from a few to 70 wtppm (see Figure 7). The higher concentrations are associated with the regolith on the old titanium-rich basaltic Maria of the Moon, and the lower contents are associated with the Highland rocks and Basin Ejecta. Clearly the higher concentrations are in the most accessible and minable material. Using the data available, it is calculated that roughly a million metric tonnes of He3 are still trapped in the surface of the Moon [1] (see Table 2).

The next step is to determine the most favorable location for extracting this fuel. Cameron [2] has shown that there is an apparent association between the helium and TiO_2 content in the samples. Assuming that this is generally true, he then examined the data on spectral reflectance and spectroscopy of the Moon which showed that the Sea of Tranquility (confirmed by Apollo 11 samples) and certain parts of the Oceanus Procellarium were particularly rich in TiO_2. It was then determined, on the basis of the large area (190,000 km^2) and past U.S. experience, that the Sea of Tranquility would be the prime target for initial investigations of lunar mining sites. This one area alone appears to contain more than 8,000 tonnes of He3 to a depth of 2 meters. Backup targets are the TiO_2-rich basalt regolith in the vicinity of Mare Serenitatis sampled during Apollo 17 and areas of high-Ti regolith, indicated by remote sensing, in Mare Imbrium and other mare of the lunar western hemisphere [2].

IV.C How Would the He3 be Extracted?

Since the solar wind gases are weakly bound in the lunar regolith it should be relatively easy to extract them. Pepin [3] found (Figure 8) that heating lunar regolith caused the He3 to be evolved above 200° C and by 600° C, approximately 75% of the He gas could be removed.

There are several methods by which the He could be extracted and a schematic of one approach is shown in Figure 9. In this unit, the loose regolith, to a depth of 60 cm, is scooped into the front of the robotic unit. It is then sized to particles less than 100 microns in diameter (about

HELIUM-3 CONTENT OF LUNAR REGOLITHS

LOCATION	% LUNAR SURFACE	AVE. HELIUM CONC. wtppm	TONNES He3
MARIA	20	30	600,000
HIGHLANDS & BASIN EJECTA	80	7	500,000
		TOTAL	1,100,000

Table 2. Helium-3 Content of Lunar Regoliths

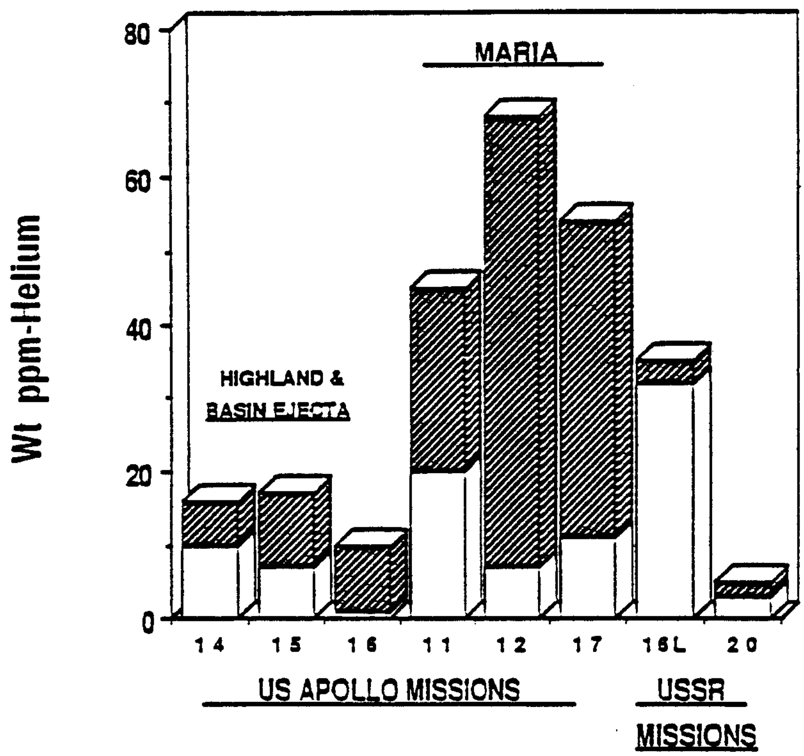


Figure 7. Range of helium concentration measured in U.S. Apollo and USSR Luna samples. Cross-hatched region gives range.

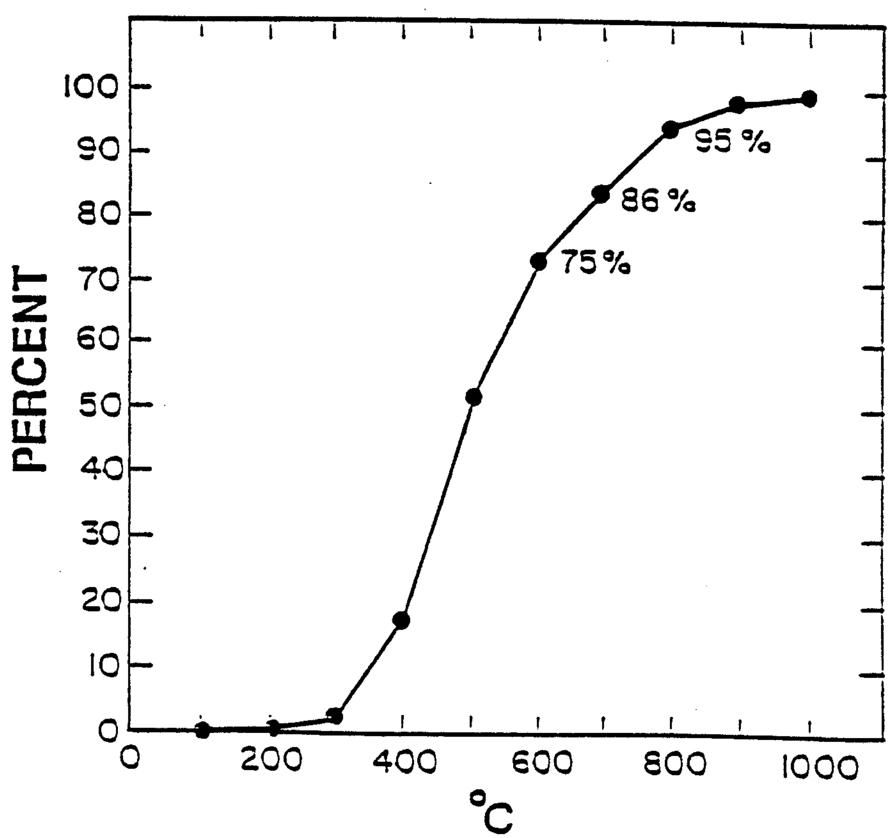
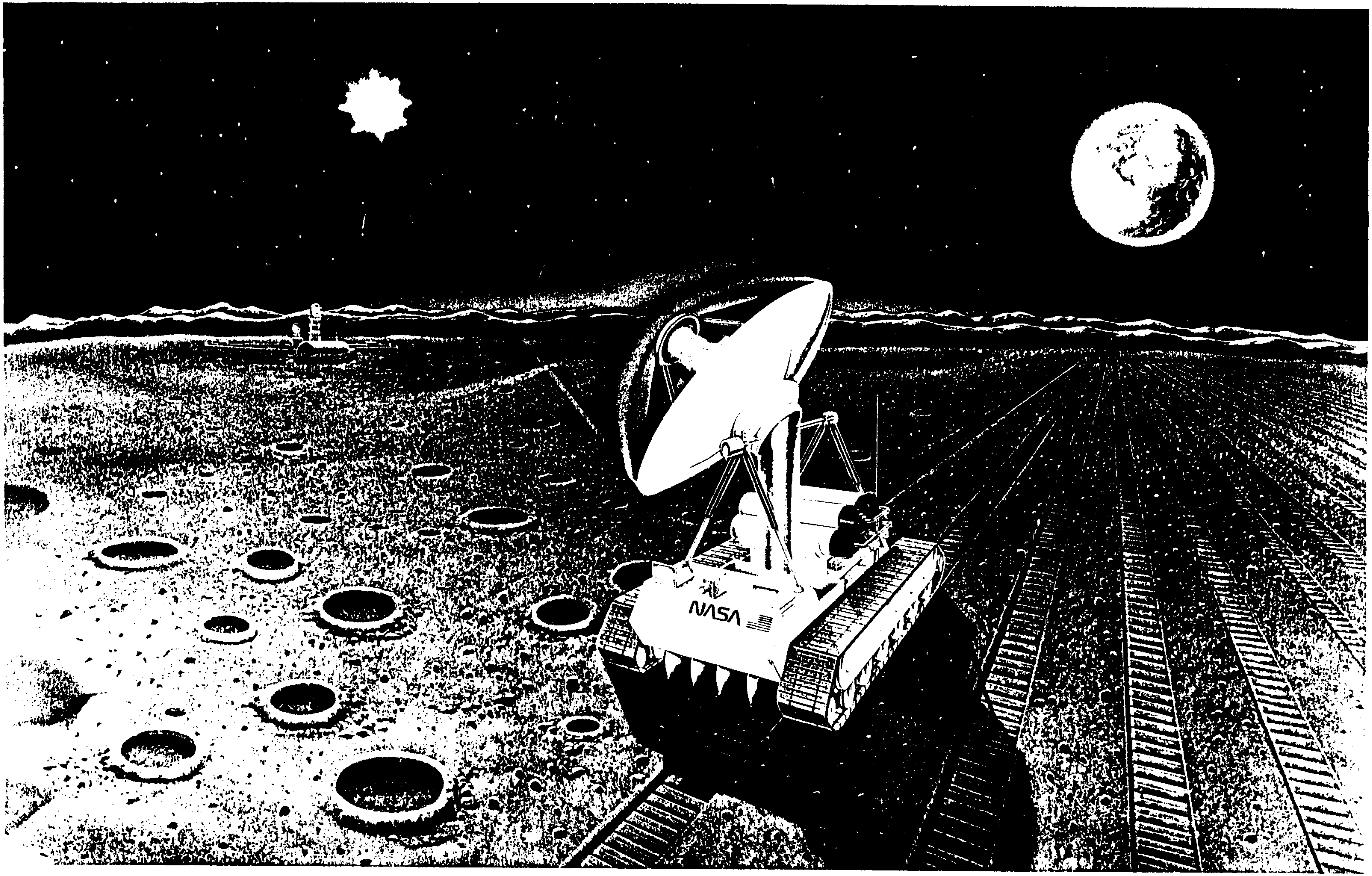


Figure 8. Evolution of He3 from lunar regolith as measured by Pepin [3] in 1970.

Figure 9. Design of lunar vehicle to extract He3 from regolith using direct solar radiation.



65% of the regolith) because there seems to be a higher concentration of solar gases in the smaller particles (presumably because of the high surface to volume ratio). After beneficiation, the concentrate is preheated by heat pipes [4] and then fed into a solar-heated reaction chamber. At this point, it is anticipated that heating to only 600 or 700°C is required, and the volatiles (H_2, He4, He3, H_2O, C compounds, N_2) are collected. The spent regolith concentrate is discharged through recuperative heat exchangers to recover 90% of its heat. The spent regolith is finally dropped off the back of the moving miner. Note that in the 1/6 gravity environment, relatively little energy is expended lifting material.

Of course, this solar energy-driven scheme would only work during the lunar day, but orbiting mirrors, nuclear reactor heat from a mobile power plant, or indirect radiofrequency (RF) heating from electricity generated at a central power plant on the Moon could extend the operating time. Alternative schemes are being examined through parametric analyses of such variables as particle size vs. temperature vs. yield, mining depth vs. He3 concentration vs. particle size distribution, manned operation vs. robotic operations vs. maintenance costs, mechanical particle separation vs. gaseous particle separation vs. yield, solar vs. nuclear power, etc.

Once the lunar volatiles are extracted, they can be separated from the helium by isolation from the lunar surface and exposure to outer space (< 5 K) during the lunar night. Everything except the helium will condense and the He3 can be later separated from the He4 by superleak techniques well established in industry [1].

For every metric tonne (1000 kg ≈ 2200 pounds) of He3 produced, some 3100 tonnes of He4, 500 tonnes of nitrogen, over 4000 tonnes of CO and CO_2, 3300 tonnes of water, and 6100 tonnes of H_2 are produced (see Figure 10). The H_2 will be extremely beneficial on the Moon for lunar inhabitants and for propellants. Transportation of that much H_2 to the Moon, even at 1000 \$/per kg (about 1/10 of present launch costs), would cost ~ 6 billion dollars. As noted below, the He3 itself could be worth as much as ~ 2 billion dollars per tonne. Of the other volatiles, the N_2 could also be used for plant growth, the carbon also for plant growth, for manufacturing or atmosphere control, and the He4 for pressurization and as a power plant working fluid. Oxygen, either from the water or carbon compounds, could be used for interior atmospheres or for fuel in rockets from the Moon.

The environmental impact to the Moon as a result of this type of volatile extraction would be minimal. For example, there would be "tracks" on the Moon and the surface would be smoothed and slightly "fluffed up" as the spent regolith is redeposited. The vacuum at the lunar surface might also be temporarily affected but, due to the low gravity level, most of the gas atoms will leave the surface of the Moon during the lunar day.

IV.D <u>How Much is the He3 Worth?</u>

While it is hard to anticipate the cost of energy in the future, one can anticipate what we might be willing to pay for fuel based on today's experience. First of all, it is worthwhile to get a feeling for how much energy is contained in the He3 on the Moon. If the ultimate resource base is 1 million metric tonnes, then there is some 20,000 TW-y of potential thermal

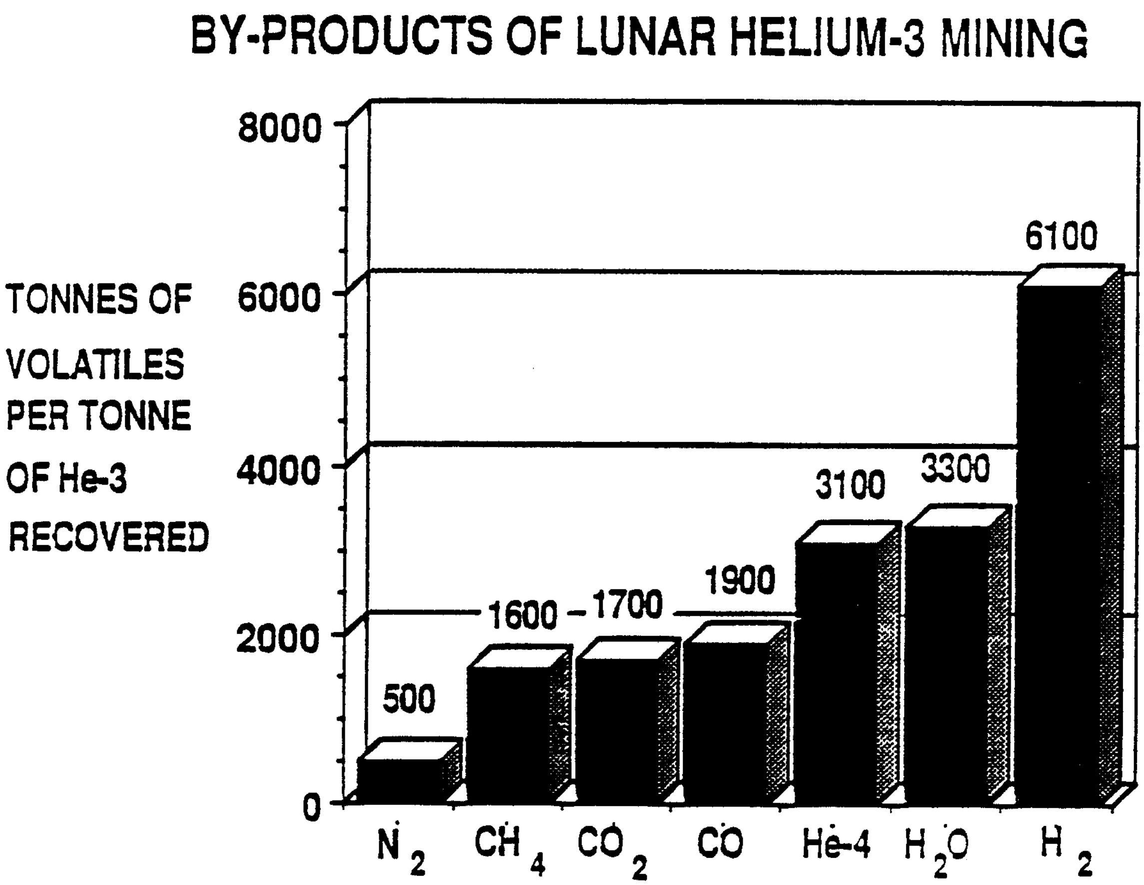


Figure 10. By-Products of Lunar Helium-3 Mining

energy on the Moon. This is over 10 times more energy than that contained in economically recoverable fossil fuels on earth. This amount of energy is also 100 times the energy available from economically recoverable U on earth burned in Light Water Reactors on a once through fuel cycle or roughly twice the energy available from U used in Fast Breeder Reactors.

The second point is that only 25 tonnes of He3, burned with D_2 in a Ra [5] type reactor, would have provided the entire U.S. electrical consumption in 1987 (some 285,000 MWe-y). The 25 tonnes of condensed He3 could fit in the cargo bay of a spacecraft roughly the size of the U.S. shuttle.

A third point is that in 1987, the U.S. spent over 40 billion dollars for fuel (coal, oil, gas, uranium) to generate electricity. This does not include plant or distribution costs, just the expenditure for fuel. If the 25 tonnes of He3 just replaced that fuel cost (while the plant and distribution costs stayed the same) then the He3 would be worth approximately 1.6 billion dollars per tonne. At that rate, it is the only thing we know of on the Moon which appears to be economically worth bringing back to earth.

An obvious question at this point is how much does it cost to obtain He3 from the Moon? The answer to that depends on three things:

(1) Will the U.S. develop a Moon base for scientific or other mining operations without the incentive of obtaining He3?
(2) If the answer to the above question is yes, then how much will the incremental costs of mining He3 be after manned lunar bases are already in place?
(3) How will the benefits of the side products be treated? For example, will one be able to "charge" the lunar settlement for the H_2, H_2O, N_2, He, or carbon compounds extracted from the lunar regolith?
(4) Will the ultimate export of volatiles to a Mars settlement add a significant rate of return to the enterprise?

The answer to question 1) may be yes. In a 1987 report to NASA, by the Ride Commission [6], it was stated that one of the 4 major future programs in NASA should be a return to the Moon and the establishment of a manned base early in the 21st century. This recommendation was made without any reference to the He3 mining possibilities. At this time, it appears reasonable to assume that the cost of returning to the Moon will be borne by the U.S. government or by an international entity as a general investment in science.

The answer to question 2) cannot be given at this time but should be the subject of study in the near future. It appears that, based on the mobile mining concept described earlier, that the equipment required to produce 25 tonnes per year could be transported to the Moon for well under 30 billion dollars (e.g., at 1000 $/kg this would allow 30,000 tonnes to be transported to the Moon). Operational costs should be well under a billion dollars per year even if no use of lunar materials is allowed. The above costs are to be compared to 500-1000 B$ in revenue from the He3 mining during the useful life of the equipment.

The possibilities of "selling" the by-products of the He3 to lunar colonies is also very intriguing. The by-products from mining just one tonne of He3 would support the annual lunar needs (properly accounting for losses through leakage and through waste recycling) of [7]:

1,400 people for N_2 (food and atmosphere)
22,000 people for CO_2 used to grow food
45,000 people for H_2O.

If the cost of transporting the equipment to extract these volatiles from the lunar regolith is written off against the savings in sending up life support elements such as H_2, N_2, or carbon for manned lunar bases, then it is possible that the cost of He3 may in fact be negligible. If that were true then the cost of electricity from D-He3 fusion power plants would indeed be much cheaper than from DT systems and possibly even from fission reactors (without taking credit for all the environmental advantages of the D-He3 fuel cycle).

To answer the question posed by the title of this section, it appears that a realistic figure for the worth of He3 on the earth is ~ 1 or 2 billion dollars per tonne (1000 $/g). This should allow D-He3 fusion plants to be competitive with DT systems and provide adequate incentive for commercial retrieval from the Moon. This latter point is currently the subject of a separate study by NASA.

IV.E What is the Current Attitude Toward He3 Development?

The current domestic and international policy environment may require significant modification to enhance the development of helium-3 fusion power on earth or helium-3 mining on the Moon. Policy issues that may affect the ultimate availability of helium-3 fusion power include the following:

1. U.S. Commitment: There is no firm commitment by the U.S. Department of Energy to the development of commercial helium-3 fusion power or by NASA to the creation of a space and lunar infrastructure that would support such a commitment. However, the two agencies now meet on a regular basis to coordinate research into D-He3 fusion and it is possible that such efforts could provide the basis for a coordinated program.

2. Soviet Commitment: There have been strong indications that, beyond a research interest in helium-3 fusion, the Soviets have focused their deep space related development on Mars rather than on lunar resources. However, recent public statements by Soviet space and fusion researchers at the Kurchatov Institute in Moscow suggest that D-He3 fusion and lunar He3 are of increasing interest to them.

3. U.S.-Soviet Cooperation: The lack of long range U.S. goals related to helium-3 fusion and the apparent focus of long range Soviet goals on Mars suggest that near term cooperation related to helium-3 mining on the Moon is unlikely unless a specific new stimulus is provided.

4. European Potential: 1992 will see a major step toward a United States of Europe with the technical and economical potential to be a major player in helium-3 fusion and lunar resource development. Indeed, Europe will have the potential to "go it alone" even though it may or may not decide to use that capability. It is not clear that the rest of the world has fully recognized this looming change in Europe's status as a "Great Power." In any case, preliminary investigations of the use of He3 in NET, the Next European Torus, have been conducted and experiments in the European JET device have released 100 kW of thermonuclear power from the D-He3 reactor, a world record!

5. Asian Potential: Several Pacific rim nations, in aggregate, also have the technical and economic potential to be a major player in helium-3 fusion and lunar resource development. This potential will be enhanced if China becomes associated with these nations. The difficulties of Asian cooperation, however, appear to significantly exceed those of Europe.

6. Third World Desires: The Third World nations (i.e., Group of 77) can be anticipated to push for inclusion in the distribution of economic benefits from any helium-3 enterprise and possibly in the actual management of a lunar mining enterprise.

7. International Cooperation: Existing international arrangements (e.g., the Moon Treaty and INTELSAT) may provide the basis for future cooperation in helium-3 fusion development and lunar helium-3 production. In this context, the ITER agreement between the United States, the USSR, Japan, and the European Community, with China and Canada in associate status, may provide the basis for initiating such cooperation.

8. Environmental Protection: A qualitative net assessment of the environmental benefits of helium-3 fusion appears to be strongly in favor of its development when the full environmental impact of fossil and fission fuels is considered. However, the general emotional resistance to the development of nuclear power in the U.S. may prolong decision making related to helium-3 fusion.

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V. RELEVANT LAW AND PRECEDENTS*

At present, there is no detailed or generally recognized and accepted legal code governing the potential exploitation of He3 or other mineral resources on the Moon. There are, however, a variety of broader legal principles and precedents which are relevant in that they:

(1) define the parameters and outer structure and contours of any probable international lunar mineral resources regime;
(2) suggest the types of policy choices which will have to be made in this respect; and
(3) provide precedents, models, and a body of experience which will influence discussion and choices as to the nature and structure of any lunar mineral resource regime which ultimately emerges.

In theory, any enquiry into the legal regime applicable to the exploitation of lunar resources should look first at existing "space law" and precedents, as the most directly applicable and relevant. We will see, however, that "space law" in its present stage of development leaves many important questions unanswered. Consequently, it is necessary to also look for guidance to other types of law and precedents--established principles of resource exploitation within different legal systems, broader principles of general international law, and international experience in developing regimes governing the exploitation of minerals or technology. Examples include organizations such as INTELSAT, as well as Antarctica and the seabeds under the High Seas. Since developing space law has drawn heavily upon some of these earlier precedents, we will discuss them first before turning more directly to the relevance of existing "space law" itself, and to our conclusions as to the present law applicable to lunar resource exploitation.

In the preparation of Chapter V, we have drawn particularly on material in the following sources: "The Moon Treaty," Hearing Before the Committee on Commerce, Science and Transportation, U.S. Senate, 96th Congress, Second Session on Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (July 29 and 31, 1980) (Ser. No. 96-115) and three studies contained in "Agreement Governing the Activities of States on the Moon and Other Celestial Bodies," prepared at the request of Hon. Howard W. Cannon, Chairman, Committee on Commerce, Science and Transportation, U.S. Senate, 96th Congs. 2nd Session (Committee Print): Parts 1 and 2 (May 1980); Part 3 (August 1980), and Part 4 (November 1980); L. Henkin, P.C. Pugh, O. Schachter, and H. Smit (Eds), International Law (2nd Ed.) (West Pub. Co., St. Paul Minn. 1987); L. Kimball, "Special Report on The Antarctic Minerals Convention," (International Institute for Environment and Development - North America; July 1988); and F. Orrego Vieuna (Ed); Antarctic Resources Policy: Scientific, Legal and Political Issues (Cambridge U. Press; 1983); S. Williams, "The Law of Outer Space and Natural Resources," Vol. 36, International and Comparative Law Quarterly (Jan. 1987), p. 142; C. Joyner, "Legal Implications of the Concept of the Common Heritage of Mankind," Vol. 35, International and Comparative Law Quarterly (Jan. 1986), p. 190; and International Law Association, Sixtieth Report - Material (1982), "Report of the Space Law Committee," pp. 12, 479-530.

V.A <u>What Counts as International Law?</u>

Since this discussion concerns, to a considerable extent, the existing and prospective international law applicable to mineral and other activities on the Moon, it may be useful to briefly explain what we mean by international law and how international law is established and determined.

International law is the law of the present international political system--which is, of course, based on the coexistence, on the Earth, of some 160 sovereign territorially-based states. It consists of the body of principles, rules, institutions, and procedures through which states mutually regulate their relations, establish a considerable extent of predictability in their interactions, and attempt to process and resolve their disputes. There are, as in any legal system, problems in ensuring compliance with international rules--particularly those attempting to control the use of coercion. But states, for a number of reasons, usually find it in their interest to comply with international law and the international legal order generally works; as observed by one scholar, "most states comply with most of international law most of the time." There is reason to expect that this will also be the case with respect to the activities of states in outer space and on celestial bodies, including the Moon. Consequently, it seems appropriate to apply traditional international legal concepts and methods of analysis to our discussion of alternative regimes for the mining of He3 on the Moon.

Very briefly, the traditional "sources" of international law--or, put otherwise, the way in which nations establish or evidence the existence of particular international law rules--are: (1) treaties (or international agreements), (2) international customary law, and (3) general principles of law commonly recognized by most major national legal systems. These sources are essentially based on either express or implied consent on the part of the States bound by the law; that is, a state is rarely in the position of being bound by international rules to which it did not at least initially consent or acquiesce.

Treaties (or international agreements) are the easiest and most important way of establishing international rules, particularly with respect to highly complex or newly emerging problem areas such as space, telecommunications or resource conservation or exploitation where detailed regulation may be required. However, a Treaty, like a contract, is binding only on those states that expressly consent to be legally bound to it. They usually give such consent by formally ratifying the agreement in accordance with their internal constitutional processes; signature alone is usually not sufficient. The U.S., of course, has special constitutional and other internal legal procedures which must be complied with before it can become legally bound to an international agreement. Moreover, many multilateral treaties require ratifications by a certain number or mix of states before the Treaty formally "enters into force" or becomes legally binding. In some cases, states may be permitted, expressly by the Treaty or by customary law if the Treaty is silent, to enter "reservations" somewhat restricting or varying the legal obligations they would otherwise assume under the provisions of the Treaty.

In contrast to treaties, customary international law is binding on all states without any requirement of express consent. However, customary law can be difficult to establish since it is necessary to prove both that (1) there is a widespread "practice" among states conforming to (or at least not specifically objecting to or opposing) the purported rule, and (2) that states follow this practice because they regard the rule as being normatively binding, rather than simply a matter of convenience. General principles of law common to most legal systems may also in certain circumstances be drawn upon by the international legal system.

There are complex relations between these various sources. For example, resolutions, declarations or other actions of international organizations, such as the U.N. General Assembly, or even provisions of a very widely accepted Treaty, may be argued to evidence the existence of an international customary rule. Conversely, a rule of customary international law may be argued to have simply been "codified" in an international Treaty, with the consequence that it remains binding on all states even if they fail to become parties to the Treaty or subsequently withdraw from it.

These principles have considerable relevance in the explanations and analysis which follows.

V.B Terrestrial Mining Law - Principles, Patterns, and Trends

All Terrestrial mining law currently in force derives from national sovereignties. Each country has enacted its own laws governing discovery and exploitation of mineral resources within its own boundaries.

V.B.1 National Systems of Mining Law

The system of mining law enacted by a given nation depends primarily on whether there is private ownership of mineral-bearing lands, public ownership, or some combination of both, as in the United States. If both types of ownership exist in a nation, there is a system covering each type.

On privately owned mineral lands, three alternative situations are possible, as follows:

1. The land and its mineral rights may be owned outright by the prospective miner or acquired by purchase.
2. The rights to minerals may be owned by one party, but one or more of timber rights, surface rights, and water rights may be owned by others.
3. Mineral rights, with or without other rights, may be leased from the owner by the prospective miner. Leases usually provide for payment of royalties to the owner, based on production.

In general, ownership or lease of mineral rights carries with it the right to disturb the ground for purposes of mining, although such action may be subject to government regulation.

Public ownership of mineral lands has its roots in the ancient doctrine of sovereign or regalian rights, under which mineral resources were the property of the crown. Under public ownership, in countries in which private enterprise has a role in development of mineral resources, two general types of systems have been employed:

1. The mining claims system. This type is exemplified by the system set up in the United States under the Mining Law of 1872, still in force for most minerals on those Federal public lands that have not been withdrawn from mineral entry. Under that law, the prospective miner stakes out a claim or claims, of a size prescribed in the law, covering land thought to be mineral-bearing. He thus acquires the right to prospect and to mine any mineral deposit discovered on the claimed land. A mining claim system may or may not provide procedures for subsequent transfer of the land from public to private ownership.

   A mining claims system may apply to all categories of mineral resources or only to certain categories, title to the remainder being reserved to the state.

2. The concession (leasing) system. Title to mineral resources covered by a concession system is reserved to the state. Concessions may be awarded either on a noncompetitive basis or on the basis of competitive bidding. In the U.S., the concession system was introduced by the Alaskan Coal Lands Leasing Act of 1914 and expanded under the General Leasing Act of 1920 and subsequent legislation. Concessions are of two general types:

   a. Concessions granting exclusive rights to specified areas of land for purposes of prospecting and exploration. Generally, but not always, if the concession holder finds a mineral deposit, he is assured of the right to mine it, under a subsequently negotiated mining concession.
   b. Mining concessions, under which conditions of mining are prescribed.

Under either a mining claims system or a concession system, the miner is required to conform to environmental and other government regulations. The two types of systems have advantages and disadvantages both from the standpoint of the state and that of the miner, but successful development of mineral resources has been achieved under both. Use of these systems is of long standing. In recent years, however, alternatives have been used in certain countries. Contracts for specific mineral developments may be awarded to private enterprise, as in certain cases in Venezuela and Colombia. Alternatively, as in the case of the Carajas iron ore deposit in Brazil, development may be conducted by a partnership of private enterprise and government. In countries like the Soviet Union, where private enterprise plays no role in mineral development, mining law consists of whatever rules and regulations are laid down by government entities responsible for specific mining operations.

No two nations have identical systems. In some nations, changes in the rules have been frequent. Such changes produce an instability that can be a serious obstacle to development of mineral resources, since they threaten security of tenure.

V.B.2 The Historical Background of Terrestrial Mineral Development

It is probable that the development of lunar resources will be an international effort. Current thinking appears to be that the major participants will be the U.S., the USSR, a bloc of European nations, Japan, and possibly China. A realistic approach to the problem of legal frameworks requires that the historical record of each of those participants in development of terrestrial resources be taken into account. That record indicates the arrangements to which each of the potential participants is accustomed, and it suggests the kinds of arrangements they might be willing to accept for the development of lunar resources.

In the Soviet Union, private enterprise has no role in mineral resource development. Specific projects are assigned to one or the other government entity. It is important to note that mineral enterprise in the Soviet Union has been an integral part of overall Soviet policy, and each project has been supported in proportion to its importance to that policy. Soviet policy with respect to mineral resources has had three major objectives:

1. to make the country as self-sufficient as possible in mineral supplies,
2. to provide an economic base for settlement of Asiatic Russia, and
3. to derive foreign exchange from exports of certain minerals, such as chromite and manganese ore, that the USSR possesses in abundance.

The first objective has been pursued vigorously since World War II. Soviet policy has in large measure achieved its objectives. Costs of some projects are reported to be enormous, but costs have not always been a prime consideration. Although Soviet Russia is now nearly self-sufficient in minerals, it has a few deficiencies. These have been supplied very largely by imports from satellite countries, including Cuba.

Japan's approach since World War II has been quite different. Mineral resource projects are carried out by private enterprise, but there is close cooperation and collaboration between industry and government, and mineral activities of industry are closely integrated with national mineral policy. That policy is conditioned by the fact that Japan, overall, is a mineral-poor country that has become increasingly industrialized during the twentieth century. The concept of the Greater East Asia Co-Prosperity Sphere, developed prior to World War II, was essentially a policy aimed at assuring Japan of access to necessary mineral supplies. Mineral policy since World War II has had the same objective. The objective has been achieved by encouraging development of a diversity of sources of mineral supplies in other countries, mainly in the non-Communist world, so as to avoid dependence on any one country. Japanese industry has not usually become directly involved in mineral enterprises in other countries, but it has financially aided such developments in return for long-term contracts for the mineral products. However, when necessary, government has provided financial aid to Japanese companies so that specific requirements of its policy could be met. Japanese policy is strictly pragmatic; it is not concerned with moral or ideological issues.

U.S. policy, both at home and abroad, assigns the major role in development of mineral resources to private industry. Government's role, except in times of emergency, has been to provide the legal framework under which private industry may operate. The broad outlines of present U.S.

mineral policy stem from the report of President Truman's Materials Policy Commission, which appeared in 1952. The Commission recognized the dependence of the U.S. on imports of certain minerals and forecast that dependence would increase with passage of time. It concerned itself with identifying the political and other conditions that would encourage private capital to discover and develop mineral resources abroad, particularly in the Less Developed Countries (LDC's). It defined conditions that would (a) allow fair returns on investment of private capital and (b) provide adequate returns to the countries in which mineral discoveries were made. The U.S. might assist indirectly through negotiation of general agreements with specific countries but would not collaborate with private industry or intervene in specific cases. When the wave of expropriations swept through the LDC's beginning in the 1950's, the U.S. did not intervene. Collaboration between U.S. government and private industry has in general been politically unacceptable. In contrast to the USSR and Japan, the U.S. has no clearly defined long-term mineral policy aimed at assuring supplies of essential minerals. American mineral industry and the availability of mineral supplies from abroad are governed mainly by the workings of the international marketplace, as recognized and recommended in the report of the National Materials Policy Commission in 1973. The National Materials and Minerals Policy Act of 1980, which calls for development of a national mineral policy, has been implemented only to a limited extent.

Western European nations offer a spectrum of mineral policies. That of the United Kingdom is close to that of the U.S., assigning a strong role to private enterprise, but government support of industry in foreign mineral development is not precluded. The policy of France is close to that of Japan, but government-industry collaboration is less conspicuous. Private enterprise is active in mineral development in Norway. Norway retains title to her share of the oil and gas resources of the North Sea, but exploitation is accomplished through concessions granted to foreign oil companies. Neither Norway, nor Germany in recent decades, has been active in development of foreign mineral resources. In Sweden and Finland, government participates in mineral industry.

In the past, under China's Communist regimes, private industry had no part in development of mineral resources. That policy has changed in recent years, and private industry is now playing an increasing role.

V.B.3 Implications for the Development of Lunar Resources

If the system of lunar mining law ultimately formulated is based on governance of the Moon by an international body, national systems of mining law will not be applicable. Private ownership of mineral or other lunar resources may not be permitted, and title to mineral resources may reside in the governing body. For the U.S., a main question is: Under such systems, how can private enterprise play a significant role in discovery and development of lunar resources? The following are possibilities:

a. Projects are selected by the governing body. Actual work is contracted to private companies or consortia of companies.

b. Proposals are received from private companies or consortia of companies. Upon approval by the governing body, concessions covering specific areas or resources are then granted. In return, the concessionaires pay rent and/or royalties to the governing body.

c. Concessions are awarded to private companies or consortia on the basis of competitive bidding.

d. Concessions are awarded to participating nations or consortia of nations, who may or may not contract the work to private enterprise.

The above alternatives are not mutually exclusive. In fact, a system that embodies all four alternatives may be the only means of reconciling the basic differences in approach to development of mineral resources that are summarized in the preceding section.

V.C Antarctic Treaty System

Perhaps the closest Terrestrial analogue to the physical, regulatory and other problems humanity is likely to encounter on the Moon is international experience regarding Antarctica. Certainly, the Antarctica shares with the Moon such distinctive features as a uniquely harsh and hostile environment, the absence of established territorial jurisdiction or human settlement, the significance of scientific uses, the cost and technological requirements of conducting activities, and the complexity of potential management problems. Space law has already drawn heavily on Antarctic precedent and, particularly in view of the recent conclusion of an Antarctic Minerals Convention, it is highly likely that any eventual lunar mineral regime will continue to look to and invoke some of this developing Antarctic experience. Consequently, it is worth examining in some detail.

The existence of Antarctica as a continent was not established until the 1820's, and it was 1899 before men first wintered over on Antarctic shores and 1911 before Amundsen and then Scott first reached the South Pole. Only in the 1930's was there the beginnings of systematic scientific exploration of this barren, extremely inhospitable and almost lifeless continent. By 1956, seven nations (Chile, Argentina, the U.K., Norway, Australia, New Zealand, and France) had formally made claim to particular areas, covering about 80 percent of the continent, despite the doubtful validity of any international legal basis for the assertion of sovereignty in Antarctic circumstances. (International law has generally required that priority of discovery and exploration be followed by "effective occupation" in order to confer sovereignty over previously unclaimed territory.) However, since other states refused to recognize these claims, and even the claimant states had disputes as to their respective claims, the resulting legal situation was very uncertain and chaotic. In particular, the U.S. and USSR, despite extensive exploration and other activities in Antarctica, both refused to recognize any claims by others and refrained from making claims themselves (although they reserved the right to do so).

V.C.1 The Antarctic Treaty of 1959

The success of the 1957-58 International Geophysical Year, which involved extensive and coordinated international scientific research in Antarctica, made apparent the need to establish some legal arrangement which would provide a stable basis for continuing scientific activities and international cooperation on the continent. Following extensive negotiation, the twelve governments then most active in Antarctica--the 7 claimant nations plus the U.S., Soviet Union, Japan, South Africa and Belgium--in 1959 concluded the Antarctic Treaty, which entered into force in 1961 upon ratification by all twelve governments.

The provisions of the Treaty of particular relevance are as follows: the Preamble recognizes "that it is in the interest of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord." The Treaty is binding on the parties for at least 30 years and is applicable to the area south of 60° south latitude. Military activities of any nature, nuclear explosions, and the disposal of radioactive wastes are prohibited in the area, but military personnel and equipment may be used for scientific research or any other peaceful use. To ensure observance of these provisions, any party may at any time unilaterally carry out inspections or aerial surveillance anywhere in the Treaty area. Provision is made for scientific cooperation and exchange of scientists and information. The Treaty does not attempt a final solution of the claims problems, but instead sets the problem aside, at least temporarily, by "freezing" existing legal positions and establishing a moratorium on new claims while the Treaty is in force. The Treaty also provides that each of the parties undertakes to exert appropriate efforts, consistent with the UN Charter, to the end that no one engages in any activity in Antarctica contrary to the purposes and principles of the Treaty. Other states are permitted to accede to the Treaty.

The Treaty does not establish a formal international organization or regulatory structure. However, it does provide an important procedure for continued consultation and the development of further cooperative arrangements among the parties. Article IX provides that the parties shall meet periodically to exchange information, consult together on matters of common interest pertaining to Antarctica, and to formulate, consider and recommend to their governments measures in furtherance of the principles and objectives of the Treaty. However, the nations parties which are entitled to appoint representatives to participate in such so-called Consultative Meetings are only the original 12 nations parties plus any nation Party which has subsequently acceded "during such time as that contracting party demonstrates its interest in Antarctica by conducting substantial scientific research or activity there, such as the establishment of a scientific station or the dispatch of a scientific expedition." That is, a nation subsequently acceding to the Treaty which does not engage in substantial activities is a party to the Treaty but is not considered a "consultative party" entitled to participate in the Consultative Meetings held under Article IX or to participate in making recommendations. Any such measures recommended by the representatives to these meetings to their governments become effective when unanimously approved by all of the Consultative Parties.

In summary, the Antarctic Treaty is in many respects fairly conservative in its reach. It does not place Antarctica under any type of international control, establish any separate international organization concerned with Antarctica, in itself purport to establish any joint control or condominium by the Treaty parties over Antarctica, or in itself provide any compulsory mechanism to enforce its obligations. It establishes only: (1) a limited framework of principles and rules applicable as among the Treaty Parties to their Antarctic activities, and (2) a mechanism for their continued consultation on a periodic basis through Article IX Consultative Meetings. Any additional rules recommended by representatives at the Consultative Meeting must be unanimously approved by the Consultative Parties before they have legal force. It may be emphasized that, while the Treaty provides that any state may become a Party, it in effect establishes a two-tiered system of participation, in which some Parties--the original Parties and other acceding states which qualify as Consultative Parties--have substantially greater decision-making authority than others. This differential status is ostensibly related to the rational and "neutral" criterion of demonstrated interest in Antarctica. However, in practice, many nations may not have sufficient wealth or technical skill to maintain or support substantial Antarctic activities. Consequently, this arrangement remains controversial.

In the more than quarter-century since the Treaty was concluded, the Treaty regime has been remarkably successful. There are now 38 parties to the Treaty, 22 of which qualify as "Consultative Parties". Moreover, the Parties, through their actions under the Treaty during this period, have created a distinctive legal and political regime, more substantive and far-reaching than the text of the Treaty itself might suggest. The Treaty framework has now been supplemented by established ways of working together, a broad network of informal arrangements and cooperative practices, a large number (150) of recommendations developed at Consultative Meetings; the negotiation of several important international agreements (such as the 1972 Convention for the Conservation of Antarctic Seals, the 1980 Convention on the Conservation of Antarctic Marine Living Resources, and the 1988 Mineral Resources Convention), and the gradual emergence among the Parties of a sense of commitment to and pride in the unique system they have created. By and large, the Treaty has been carefully complied with, although some environmental groups have recently alleged instances of noncompliance into certain obligations, particularly with regard to waste disposal. There have been a variety of suggestions from states in the UN which are not Parties to the Treaty and from nongovernmental organizations that Antarctica be placed under UN jurisdiction or made an international park, that the authority of the Consultative Parties be limited, and so forth. But, in practice, other nations and international organizations have generally deferred to the role of the Antarctic Treaty Parties in the management of Antarctic problems, although pressures from the U.N. General Assembly to place the continent and Treaty system under some type of U.N. oversight continue.

V.C.2 The Convention on the Regulation of Antarctic Mineral Resources (1988)

For some years, the Treaty parties have recognized that the possibility of exploitation of Antarctic resources, particularly mineral resources, could pose a grave threat to the continued successful working of the Treaty regime. The Treaty itself does not expressly, or by implication specifically address the question of mineral resource exploration or exploitation. It is entirely silent on the question. The history of the negotiations for the Treaty indicate that the nations participating considered economic issues too controversial to deal with in the Treaty, and this omission was deliberate. However, in the late 1960's, with reports of the possibility of mineral and hydrocarbon resources on the continent and continental shelf, the question could no longer be ignored. Clearly, mineral exploration and exploitation could have serious environmental consequences, possible threatening scientific research on the continent. While the prospect for economic exploitation of these resources in the near future was remote, the mere possibility seemed to raise political and other issues. Moreover, the question of how the regulatory framework for mineral resource development was to be established and structured, and how any profits were to be allocated, threatened to revive all of the troublesome issues of territorial claims which had thus far been bypassed.

The question of mineral resources was first formally raised in the 1970 Consultative Meeting of the Parties but was temporarily deferred during the negotiation of the Convention on the Conservation of Antarctic Living Resources, which was completed in 1980. In 1981, the Parties decided to authorize special negotiations to elaborate a legal agreement to govern the possibility of minerals development in Antarctica. Following six years of negotiation, the 33 Antarctic Treaty parties on June 2, 1988 concluded and opened for ratification the Convention on the Regulation of Antarctic Mineral Resource Activities (Antarctic Mineral Resources Convention). The Antarctic Minerals Resource Convention has an obvious importance and relevance to the analogous issues of lunar mineral resource development, and, in a more extensive study, we would wish to present a very detailed description of its complex and interesting provisions. In this paper, however, we will attempt only a broad overview of its structure and more significant provisions.

The Minerals Convention regulates mineral prospecting, exploration and development, including related logistic support on the Antarctic continent and all Antarctic islands and the seabed of the adjacent continental shelf. It will enter into force when ratified by 16 of the 20 Antarctic Treaty Consultative Parties that adopted it on June 2, 1988, including a minimum of 11 developed and 5 developing nations; there are additional "entry into force" requirements to ensure that an appropriate proportion and mix of both claimant and nonclaimant nations are among those ratifying. Thereafter, it is open to accession by any nation.

The Preamble asserts certain principles basic to the establishment of the Convention and mineral resources regime, including:

- the special legal and political status of Antarctica and the special responsibility of the Antarctic Treaty Consultative Parties to ensure that all activities in Antarctica are consistent with the Treaty.
- the importance of ensuring that a regime for Antarctic mineral resources be consistent with the provisions of the Antarctic Treaty which "freeze" or set-aside the difficult issue of territorial claims.
- the concern that mineral resource activities could adversely affect the Antarctic environment or dependent or associated ecosystems and the belief that protection of the environment must be a basic consideration in decisions taken concerning such activities.
- the belief that the effective regulation of Antarctic resource activities is in the interest of the international community as a whole, and that participation in such activities should be open to all states which have an interest in such activities and subscribe to a regime governing them, and that the special situation of developing country parties to the regime should be taken into account.

In addition, Article 2 on "Objectives and General Principles" reaffirms that the Convention is an integral part of the Antarctic Treaty system and that the Parties have a special responsibility for protecting the Antarctic environment, respecting other legitimate uses of Antarctica and its scientific value and aesthetic and wilderness qualities, ensuring the safety of operations in Antarctica, promoting opportunities for fair and effective participation of all Parties, and taking into account the interests of the international community as a whole. Article 4 adds the principles that decisions about Antarctic mineral resource activities shall be based upon information adequate to enable informed judgments to be made about their possible impacts and that activities shall not take place in the absence of such information, an assessment of the possible impact of such activities, and arrangements for monitoring.

The Convention establishes a broad regulatory framework, subject to the above basic principles and standards, and implemented through certain institutions, rather than trying to provide a detailed mining code. The Convention applies to Antarctic mineral resource activities, which are broadly defined to include prospecting, exploration or development (each of which is in turn carefully defined), but to exclude scientific research. No such activities are to be conducted except in accordance with the Convention.

The Convention establishes five separate institutions: the Commission; the Special Meeting of States Parties; the Scientific, Technical and Environmental Advisory Committee; different Regulatory Committees; and a Secretariat. The Commission will be composed of all Antarctic Treaty Consultative Parties, as well as other states sponsoring mineral exploration or development or engaged in certain other kinds of activities. Commission decisions will normally be taken by a three-quarters majority vote, although some important decisions involving budgeting or financial matters, the opening up of an area of exploration or development, and certain issues of nondiscrimination will require consensus. The Special Meeting of all parties will advise the Commission whether to identify an area for possible exploration or development. The Advisory Committee, composed of all parties to the Convention, will present technical reports and advice to the Commission and Regulatory Committees. A separate Regulatory Committee will be constituted for each geographic area identified by the Commission for possible minerals exploration and development and will be composed of ten original Commission members plus Parties submitting applications or sponsoring activities in the area of competence of the Commission. The criteria for the Selection of Regulatory Committee members are very detailed and are designed to achieve an accommodation and balance between the interests of claimant and nonclaimant members. The Commission may establish a Secretariat staff as necessary.

The regulatory framework established by the Convention varies with the stage of mineral resource activity. Very broadly, prospecting is not subject to prior authorization, whereas exploration and development are prohibited unless specifically permitted. Activities must in each case be conducted by an operator under the aegis of a sponsoring state with whom the operator has a substantial and genuine link. The operator may be a Party, an agency or instrumentality of a Party, or a joint venture composed of any of the foregoing. This means the Convention expressly contemplates a possible role for private enterprise.

Prospecting, which is not subject to prior authorization, does not confer on the operator any rights to mineral resources, although the sponsoring state must ensure compliance by its operators with the principles and standards of the Convention. Operators can retain data and information of commercial value. The sponsoring state must notify the Commission well in advance of prospecting and provide an environmental assessment, monitoring, and contingency plan. There are other provisions for safeguards, removal and site rehabilitation, annual reports, inspection and liability and response actions.

If prospecting leads to interest in exploration and development, this triggers a series of further evaluations and actions by the Commission and other institutions. The process begins with a decision to "identify an area" for such activities, followed by the constitution of a Regulatory Committee for that area, and may finally result in approval of a specific "Management Scheme" and the issuance of an Exploration Permit conveying exclusive rights to the operator to explore, and subject to further reexamination and possibly modification, to develop specific mineral resources. Such activities must be carried out in accordance with the terms and conditions of the "management scheme." Again, there are detailed provisions regarding provision of information, monitoring, establishment of regulations, safeguards, liability and so forth. The Commission may, by consensus, set fees, levies or other operator payments. The Commission will determine how any surplus revenues are to be allocated, but must use these funds either (1) to promote scientific research in Antarctica and (2) "to ensure that the interests of the members of Regulatory Committees having the most direct interest in the matter in relation to the areas in question are respected in any disposition of the surplus."

Other provisions of the Convention provide for broad rights of inspection, the designation by the Commission of Specially Protected Areas or Sites of Special Scientific Interest, nondiscrimination against any Party or its operators, respect for other uses of Antarctica, availability and confidentiality of data and information, dispute-settlement, amendment, and withdrawal of a party on two years notice. The Final Act of the Conference preparing the Convention continues an agreement among the Antarctic Treaty parties for voluntary restraint on all mineral resource activities pending the entry into force of the Convention and establishment of the new mineral resources regime. The Parties also must complete a more detailed protocol covering liability and response action for environmental damages related to mineral activities.

It will be seen that the Convention is primarily a framework agreement which provides a structure for making decisions as to allowing mineral activity if and when it is proposed, rather than providing present detailed solutions to problems or a specific mining code. Any "mining code" will in effect be established by the Regulatory Commissions if and when established, and the difficult problem of allocation of any profits is left unresolved for the future. There are presently differences of opinion as to whether the Convention will encourage or discourage mineral exploitation. Some advocates of development claim that the Convention imposes excessive environmental and regulatory obstacles which will keep development from occurring. But some environmentalists on the other hand, charge that the Convention fails to provide adequate environmental protection and gives to much authority to states asserting territorial claims.

V.C.3 Some Lessons of the Antarctic Experience

The Antarctic system and experience will be relevant to the development of any lunar resource regime and has many features warranting attention such as:

- the adoption of a simple, pragmatic and flexible approach to problems, bypassing any troublesome issues of principle which do not require immediate solution (such as to the territorial claims dispute or the question of allocation of profits from any still hypothetical mineral resource activities) and focusing instead on practical accommodations to meet real problems.
- the development of institutions on a decentralized and evolutionary basis, only as and when needed, and tailored to the particular functions required.
- continuing reliance on competent scientific information and advice through groups such as ICSU's Scientific Committee on Antarctic Research, and the concept that decisions should be based only on information adequate to make sound judgments, an assessment and monitoring of possible environmental consequences.
- a pattern of recommending interim guidelines or voluntary restraints pending the development of new institutions to avoid developments which might needlessly precipitate disputes or foreclose flexibility of choice in reaching solutions.
- the use of consultative mechanisms to identify issues requiring common action and response.
- the pooling of research efforts and resources and the use of more cost-effective joint approaches.
- broad provisions for notice, consultation and inspection designed to foster mutual confidence among the participants in the system and avoid disputes.
- recognition of the basic importance of ensuring that resource decisions take due account of environmental and other broader concerns.
- recognition that all states should have access to participation in any activities and that such activities should be carried out in ways consonant with the interests of the international community as a whole.
- a sensitivity by the States to achieve both an internal accommodation and mutual compromise of their interests among themselves.
- recognition to achieve an external accommodation and compromise between the groups most directly involved and the broader international community which claims a legitimate interest and concern in the area.

However, the Antarctic experience also suggest some potential problems. The Antarctic Treaty System continues to experience tensions resulting from Third World perceptions that the Treaty System remains primarily an exclusive, elite, and largely Western developed nation club, to which poorer, scientifically-limited nations can be admitted only as second-class citizens. In the interest of long-term stability, the Treaty Parties will probably continue to seek ways consistent with the effective and efficient operation of the Treaty regime, to integrate the broader international community into the management regime and programs, and to give developing nations a greater sense of participation and stake in the systems.

V.D The Law of the Sea Convention (1982)

V.D.1 Jurisdiction over the Mineral Resources of the Seas

At present, the closest parallel to exploitation of extra terrestrial resources is exploitation of the mineral resources of the seas. Currently there is no internationally accepted general law governing those resources. Instead there are actions and conventions that establish national jurisdictions over portions of the seas. The position of the U.S. is that under international law:

1. no state may claim or exercise sovereignty or sovereign or exclusive rights over any part of the seabed and subsoil beyond the limits of national jurisdiction, or over its mineral resources, and no state or person may appropriate any part of that area;

2. unless prohibited by international agreement, a state may engage, or authorize any person to engage, in activities of exploration for, and exploitation of, the mineral resources of that area, provided that such activities are conducted

   a. without claiming or exercising sovereignty or sovereign or exclusive rights in any part of that area, and

   b. with reasonable regard for the right of other states or persons to engage in similar activities and to exercise the freedoms of the high seas;

3. minerals extracted in accordance with paragraph (b) become the property of the mining state or person.

Under the law of the United States, a citizen of the United States may engage in activities of exploration for, or exploitation of, the mineral resources of the area of the seabed and subsoil beyond the limits of national jurisdiction only in accordance with a license issued by the Federal Government pursuant to law or international agreement.

Most offshore mining operations have been confined to coastal waters, over which nations for centuries asserted jurisdiction for distances ranging from 3 to 12 nautical miles. Since World War II, there has been a growing tendency to set the limits of jurisdiction farther out, triggered by recognition that important reservoirs of petroleum underlie portions of the shelves or by a desire to control offshore fishing grounds. In 1945, President Truman proclaimed national jurisdiction over the resources of the seabed of the continental shelves adjacent to the coastlines of the United States. In 1946, Argentina proclaimed sovereignty over the adjacent continental shelf, which extends as much as 500 miles from the coastline and surrounds the Falkland Islands. Other states took similar actions. Soon after, concern over fishing grounds led Costa Rica, Chile, Ecuador, Peru, and El Salvador, later joined by Colombia, to assert jurisdiction over fishing in a zone extending outward for 200 miles from their coasts, far beyond the limits of the continental shelves of those countries. In the 1950's, recognition of deep-sea deposits of phosphate and of manganese-rich nodules containing copper, nickel, and cobalt raised anew the question of jurisdiction over deep-sea resources and led directly to an attempt to frame an international treaty governing exploitation of the mineral resources of the deep-sea basins. The resulting convention is discussed in a subsequent section of this report.

At present, there is little real law governing exploitation of marine resources. "Law" in force consists of precedents established by unilateral or joint actions that no nation has chosen to challenge. The Continental Shelf convention of 1958 sanctioned extension of jurisdictions to the continental shelves, but the convention left numerous questions of conflicting jurisdictions unresolved. Jurisdiction over the oil and gas resources of the North Sea, which lies on part of the continental shelf of Europe, was settled by negotiations among the bordering nations.

There is currently no international law governing deep-sea mineral resources. The metalliferous muds of the Atlantis Deep in the Red Sea are deep-sea deposits; jurisdiction over them was simply asserted by the bordering nations, Sudan and Saudi Arabia.

V.D.2 The 1982 Law of the Sea Convention

In the 1950's, oceanographic investigations showed that the manganese-rich nodules discovered by the Challenger Expedition of 1872-1876 were distributed widely over the deep ocean basins, and that there are also areas covered with phosphate nodules. During 1962-1978, research and development aimed at exploitation of the manganese-rich nodules were undertaken by five international consortia. Methods of recovery of the nodules and extraction of manganese, copper, nickel and cobalt from them were developed. These events focussed attention on the fact that, apart from freedom of the seas and air for purposes of navigation, there was no international law governing activities in the deep sea basins. Growing controversy led in 1974 to the first of a long series of International Conferences on the Law of the Sea, under the auspices of the United Nations. The protracted negotiations during the conferences were a series of debates between the developing nations, plus the Soviet Union, and the industrialized nations of the Free World, led by the United States. The two groups accepted the still vague principle that the resources of the sea are the common heritage of mankind, but they disagreed sharply on the conditions under which development of those resources should be permitted. The industrialized nations wanted the oceans to be open to mining by their nationals. The developing nations wanted mining to be governed by an international authority, and that view prevailed in the drafting of the Law of the Sea Convention that was finalized in 1981 and signed by 117 nations in December, 1982. Subsequently an additional 40 nations signed the treaty, but 15 other nations, including the U.S., Belgium, Great Britain, Holland, Italy, and Japan, have not signed. Note that signing does not mean ratification.

The Treaty calls for establishing an International Seabed Authority (ISA) sponsored by the United Nations with exclusive right to exploit deep-sea resources or license their exploitation. All revenues from mining would go to the developing nations. The Treaty further calls for the formation of an international mining company called the Enterprise. Treaty provisions require industrialized nations to sell their technology for deep-ocean mining to the Enterprise. Private companies may be licensed by the ISA but are required to pay fees of up to one million dollars per year and a taxation rate of up to 70 percent. Revenues are to be distributed to the developing nations at the discretion of the United Nations. The ISA is a one-nation-one-vote international body, governed by an assembly and an executive council on which the Soviet Union would have three seats, whereas the U.S. would have to compete with its allies for representation.

In refusing to approve the Law of the Sea Treaty, the U.S. objected that the treaty would deter future development of deep seabed resources, because of the lack of certainty with regard to the granting of mining contracts, the artificial limitations on seabed mineral production, and the imposition of burdensome financial requirements. It would not give the U.S. an adequate role in the decision-making process or in approval of amendments to the Convention. It would mandate transfer of private technology related to seabed mining and would allow transfer of funds received by the ISA from miners to so-called national liberation movements.

Subsequent to the signing of the Treaty, the UN set up a Preparatory Commission under the ISA. According to Marine Data Miner (Vol. 3, No. 1, July 1988), the Preparatory Commission has awarded a deep-sea mining site in the Indian Ocean to India and is expected to assign sites in the Pacific to France, the Soviet Union, and Japan. The same article notes, however, that mining cannot begin until the Treaty has been ratified by 60 nations, whereas only 34 have ratified. The United States, the western European nations, Japan, and Soviet Union have not ratified. In 1980 the U.S. Congress passed the Deep Seabed Hard Minerals Act, under which the National Oceanic and Atmospheric Administration is authorized to license deep-sea mining operations by U.S. nationals. In 1983, by presidential proclamation, the United States created an Exclusive Economic Zone extending 200 nautical miles offshore from the United States and established control over all resources of the Zone. U.S. negotiations with Great Britain, France, Belgium, West Germany, Holland, and Japan led in 1984 to an agreement to respect each other's licensing operations. In the same year, the U.S. Department of Commerce issued exploration licenses to four consortia. The licenses are for areas in the belt lying between the Clarion and Clipperton fracture zones in the Pacific Ocean.

V.E "Space Law"

The most salient place to look for rules relevant to the exploitation of lunar resources is, of course, in the developing body of "space law" which is expressly concerned with outer space and celestial bodies. However, "space law" is still fragmented and uncertain and may at most suggest only partial answers to some of the questions in which we are interested.

At the present time, "space law" consists primarily of a series of treaties and other agreements developed largely within the UN Committee on the Peaceful Uses of Outer Space (COPUOS). The most relevant agreements for our purposes are the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (the "Principles" or "Outer Space Treaty") and the 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the "Moon Agreement"). We shall also briefly discuss several other specialized agreements of possible relevance--the 1964 and 1971 Agreements establishing the International Telecommunications Satellite Consortium (INTELSAT); the 1976 Convention on the International Maritime Satellite System (INMARSAT); and the 1988 Space Station Agreement. Other "space law" treaties, which are of less immediate relevance and will not be discussed here, include the 1972 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched Into Outer Space; the 1972 Convention on International Liability for Damage Caused by Space Objects, and the 1975 Convention on Registration of Objects Launched Into Outer Space.

V.E.1 The Outer Space Treaty (1967)

The Outer Space Treaty, to which over 90 states, including the U.S. and the Soviet Union, are parties, draws heavily on the precedent of the Antarctic Treaty and is widely regarded as providing the framework or "charter" of space law. In view of its broad acceptance, many of its principles are now arguably international customary law, binding even upon nations not formally parties to the Treaty.

The Treaty establishes a broad framework for the exploration and use of outer space. As here relevant, it provides, inter alia, that:

- the exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interest of all countries, irrespective of their degree of economic and scientific development, and shall be the preserve of all Mankind (Art. I, para. 1);
- Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all states without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies (Art. I, para. 2);
- There shall be freedom of scientific investigation in outer space, including the Moon and other celestial bodies, and states shall facilitate and encourage international cooperation in such investigation (Art. I, para. 3);
- Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means (Art. II);
- The Moon and other celestial bodies shall be used exclusively for peaceful purposes and the establishment of military bases or installations or the testing of any type of weapon is forbidden (Art. IV);
- States parties shall bear international responsibility for national activities and for assuring that national activities set forth in the Treaty. The activities of nongovernmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate state party (Art. VI);
- States parties shall be guided by the principle of cooperation and mutual assistance and shall conduct their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of other parties (Art. VII);
- A State Party on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body (Art. VIII);

- States parties shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination. If a state party has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon or other celestial bodies, would cause potentially harmful interference with activities of other States Parties, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party which has reason to believe that an activity or experiment planned by another State Party would cause such potentially harmful interference may request consultation concerning the activity or experiment. (Art. IX);
- State parties agree to inform the Secretary General of the UN as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, location and result of their activities in outer space, including the Moon or celestial bodies (Art. XI);
- All stations, installations, equipment and space vehicles on the Moon or celestial bodies shall be open to representatives of other states parties on the basis of reciprocity; such representative shall give reasonable advance notice of a projected visit (Art. XII);
- the Treaty applies equally to activities carried on jointly with other states (Art. XIII);
- any state party may propose amendments to the Treaty which shall enter into force upon acceptance by a majority of states parties to the Treaty and thereafter for each remaining state on its acceptance (Art. XIV);
- a state may withdraw from the Treaty on one year's notice (Art. XVI).

The Outer Space Treaty, which is legally binding on the U.S., does not establish any specific rules regarding the exploitation of mineral resources on the Moon. It does, however, provide certain principles and contain certain other elements highly relevant to the eventual structures of any such regime. These include in particular the following:

- Activities of states on the Moon are clearly governed not only by the Treaty but by otherwise binding rules of international law including the UN charter.
- Articles I, III and the Treaty as a whole suggest that States may "use" the Moon at least for peaceful purposes and may conduct not only scientific but presumably other activities as well, arguably including mineral resources-related activities. However, under Article I states have some general and unspecified obligation to share the benefits of such exploration and use with all countries.
- Article II of the Treaty expressly excludes any claim of sovereignty over specific territory on the Moon, and Article I appears to exclude any barring of "free access" to any area of the Moon or any discriminatory exclusion of any state from the opportunity to explore or make use of the Moon. However, Article XII implicitly recognizes that states may establish stations and other installations on the Moon, with perhaps some right of exclusivity implied by the provision for advance notice of any inspection, and Article VIII implies that the state establishing such station or conducting such activities has the right to exercise jurisdiction at least over such installations and

its own personnel. Article VI implies that activities may be carried out by nongovernmental entities and Article XIII expressly contemplates joint ventures.

- Under Article IX, states clearly are obligated to avoid contamination of the Moon, but broader obligations with respect to the lunar environment are not spelled out.
- The Treaty repeatedly stresses obligations of cooperation and mutual assistance, and in Article IX expressly spells out a strong commitment to advance notification and consultation with respect to any activities which might interfere with the activities of other states (which might presumably include any large-scale mining activities).
- States are internationally liable for their activities on the Moon and are required to regulate and control the activities of any of their nongovernmental entities, for whose activities they are also presumably liable.
- The Treaty generally, and Article XI and XII in particular, appear to contemplate a wide degree of openness and exchange of data and information, but the extent of the exchanges required is not spelled out.

In sum, both the language of the Treaty and subsequent scholarly commentary upon it, suggest that, while the Outer Space Treaty does not expressly deal with the issue of exploitation of lunar mineral resources, it does not preclude such activity, including activity by individual states; indeed Article VI appears to contemplate the possibility of activities by nongovernmental entities or "private enterprise." Moreover, while the Treaty would prevent any assertion of exclusive national territorial claims to particular areas of the Moon, it contemplates the establishment of national stations and installations and the conduct of activities making "use" of the Moon. Finally, the Treaty does not appear to preclude the possibility of national or private ownership of resources removed from the Moon, though it suggests that there are some types of obligations to ensure that mining activities do not result in environmental harm or interfere with the activities of other states, and that, in some unspecified sense and to some unclear extent, activities should enure to the benefit of all countries.

In view of broad adherence to the Outer Space Treaty, including all states having significant space capabilities and the absence of any objection to its principles, it is persuasive that most of the provisions of the Treaty have now become part of customary international law, binding even upon states which have not ratified the Treaty, or even upon any state which might choose to withdraw.

V.E.2 The Moon Agreement (1979)

The Moon Agreement, which was negotiated for some seven years in the UN Outer Space Committee (COPUOS), was opened for signature on December 18, 1979, and entered into force on July 11, 1984 upon ratification by 5 states--Austria, Chile, the Netherlands, the Philippines and Uruguay. Since then it has been acceded to by two more states -- Australia and Pakistan -- for a total of seven states (as of December 15, 1988). In addition, France, Guatemala, India, Morocco, Peru and Romania have signed but not ratified the Agreement. Neither the U.S., the Soviet Union, the People's Republic of China, Japan or the U.K. are signatories or parties.

The Moon Agreement is in substantial part a reiteration of earlier "space law" instruments and draws particularly on the provisions of the 1967 Outer Space (or "Principles") Treaty. However, as its name indicates, it deals more specifically than the Outer Space Treaty with certain issues relating to the exploration and use of the Moon and other celestial bodies, including questions related to the exploitation of mineral resources, and thus is highly pertinent to our discussion. Even if the Agreement is not at this time legally binding on either the U.S. or most other major existing or potential "space powers", it is the product of lengthy negotiation and compromise by these and other states, and is likely to form the context and at least starting point for further discussion of any lunar mineral resources regime.

As indicated, many of the provisions of the agreement are in substance a repetition, as applied to activities on the Moon, of obligations already binding on the U.S. and other states parties under Outer Space Treaty. These include provisions that activities on the Moon shall be carried out in accordance with international law in the interest of maintaining international peace and security, cooperation and mutual understanding, and with due regard to the corresponding interests of other states (Art. 1); the Moon shall be used exclusively for peaceful purposes and any threat or use of force is prohibited (Art. 2); the exploration and use of the Moon shall be the province of all mankind and shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or social development, and states shall be guided by the principle of cooperation and mutual assistance (Art. 4); parties will inform the UN, the public, the scientific community and other states to the greatest extent feasible and practical of their activities (Art. 5); there shall be freedom of scientific investigation on the Moon without discrimination (Art. 6); there are general obligations to prevent the disruption of the Moon's environment (Art. 7); activities of parties shall not interfere with activities of other parties, and, should this occur, the states concerned shall undertake consultations (Art. 8(2)); parties shall bear international responsibility for national activities on the Moon, whether carried out by national or nongovernmental entities (Art. 14); and there are general rights of open inspections and obligations of mutual consultation (Art. 15):

The Moon Agreement also, however, provides certain new or additional obligations not expressly included in the Outer Space Treaty. These additional obligations are presumably not binding on states which have not expressly ratified the Moon Agreement, except to the extent that such obligations can (1) be considered to be implicit in (i.e., simply a "spelling out" of) obligations already in the Outer Space Treaty, or (2) are otherwise binding as customary international law without regard to their inclusion in the agreement. The most important of these "additional" provisions are the following:

- Language in Article 4 that, in the exploration and use of the Moon, due regard shall be paid to the interests of present and future generations as well as to the need to promote higher standards of living and conditions of economic and social progress and development. (This is probably already implicit in the Outer Space Treaty).

- Article 6(2), which provides that:

  In carrying out scientific investigations and in furtherance of the provisions of this Agreement, the States Parties shall have the right to collect on and remove from the Moon samples of its minerals and other substances. Such samples shall remain at the disposal of those States Parties which caused them to be collected and may be used by them for scientific purposes. States Parties shall have regard to the desirability of making a portion of such samples available to other interested States Parties and the international scientific community for scientific investigation. States Parties may in the course of scientific investigations also use mineral and other substances of the Moon in quantities appropriate for the support of their missions.
- Language in Article 7 that the parties shall take measures to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in the environment, by its harmful contamination, or otherwise. (This is probably already implicit in the environmental obligations established by the Outer Space Treaty and customary law.) Article 7(3) also contemplates the possible establishment of international scientific preserves.
- Article 8, which provides that States Parties may pursue their activities in the exploration and use of the Moon anywhere on or below its surface, and for those purposes may place or move freely their personnel, space vehicles, equipment, facilities, stations and installations anywhere over, on or below the surface of the Moon.
- Article 9, which provides that States Parties may establish manned or unmanned stations on the Moon, but that a party shall use only that area required for the needs of the station and install a station in such a manner as not to impede free access to all areas of the Moon by other states.
- Article 10, which provides that States Parties shall adopt all practicable measures to safeguard the life and health of persons on the Moon.
- Article 11, which because of its importance to the issue of a lunar resource regime here under discussion deserves quotation in full:
  1. The Moon and its natural resources are the common heritage of mankind, which finds its expression in the provisions of this Agreement and in particular in paragraph 5 of this article.
  2. The Moon is not subject to national appropriation by any claim of sovereignty, by means of use or occupation, or by any other means.
  3. Neither the surface nor the subsurface of the Moon, nor any part thereof or natural resources in place, shall become property of any State, international intergovernmental or nongovernmental organization, national organization or nongovernmental entity or of any natural person. The placement of personnel, space vehicles, equipment, facilities, stations and installations on or below the surface of the Moon, including structures connected with its surface or subsurface, shall not create a right of ownership over the surface or the subsurface of the Moon or any areas thereof. The foregoing provisions are without prejudice to the international regime referred to in paragraph 5 of this article.

4. States Parties have the right to exploration and use of the Moon without discrimination of any kind, on a basis of equality and in accordance with international law and the terms of this Agreement.
5. States Parties to this Agreement hereby undertake to establish an international regime, including appropriate procedures, to govern the exploitation of the natural resources of the Moon as such exploitation is about to become feasible. This provision shall be implemented in accordance with article 18 of this Agreement.
6. In order to facilitate the establishment of the international regime referred to in paragraph 5 of this article, States Parties shall inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of any natural resources they may discover on the Moon.
7. The main purposes of the international regime to be established shall include:
   (a) The orderly and safe development of the natural resources of the Moon;
   (b) The rational management of those resources;
   (c) The expansion of opportunities in the use of those resources;
   (d) An equitable sharing by all States Parties in the benefits derived from those resources, whereby the interests and needs of the developing countries, as well as the efforts of those countries which have contributed either directly or indirectly to the exploration of the Moon, shall be given special consideration.
8. All the activities with respect to the natural resources of the Moon shall be carried out in a manner compatible with the purposes specified in paragraph 7 of this article and the provisions of article 6, paragraph 2, of this Agreement.

- Article 12(c), which provides that States Parties shall retain jurisdiction and control over their personnel, vehicles, equipment, facilities, stations and installations on the Moon. (This is probably already implicit in the Outer Space Treaty).
- Article 13(2), which contemplates that more detailed arrangements regarding liability may become necessary as a result of more extensive activities on the Moon.
- Article 15, which elaborates in considerable detail the inspection and consultation rights and obligations of the parties and provides at least a rudimentary dispute-settlement procedure, possibly going beyond that provided in the Outer Space Treaty.
- Article 16, which makes it clear, that an international organization whose membership is comprised of a majority of States Parties may conduct activities under the Agreement if it declares its acceptance of the Agreement's obligations.
- Article 17, which, as does the Outer Space Treaty, permits any State Party to propose amendments to the Agreement, which shall enter into force for any State Party accepting the amendments upon their acceptance by a majority of States Parties and thereafter for each other Party on its acceptance.

- Article 18, which provides for a possible conference to review the Agreement, in the following terms:

  > Ten years after the entry into force of this Agreement, the question of the review of the agreement shall be included in the provisional agenda of the General Assembly of the United Nations in order to consider, in the light of past application of the agreement, whether it requires revision. However, at any time after the agreement has been in force for five years, the Secretary-General of the United Nations, as depositary, shall, at the request of one third of the States Parties to the agreement and with the concurrence of the majority of the States Parties, convene a conference of the States Parties to review this agreement. A review conference shall also consider the question of the implementation of the provisions of article 11, paragraph 5, on the basis of the principle referred to in paragraph 1 of that article and taking into account in particular any relevant technological developments.

Since conclusion of the agreement, there has been a continuing debate as to the meaning of some of its provisions--particularly the provisions of Article 11--and as to the agreement's potential consequences for the possibilities of the exploitation of lunar mineral resources, particularly by private enterprise. These questions were examined in depth in 1980 in a series of Congressional Hearings on "The Moon Treaty" by the Committee on Science, Technology and Space of the Senate Committee on Commerce, Science and Transportation (96th Congress, second session), as well as in a series of related studies commissioned by the Committee. The Hearings reflected, on the one hand, the then current (Carter) administration's position that the agreement adequately protected U.S. interests in the potential exploration and use of the Moon and that ratification was in the U.S. national interest. They also demonstrated opposition to the agreement by certain industry groups and others, who argued that the agreement, and particularly Article 11: (1) would create a moratorium on commercial exploitation of lunar resources until another, much more comprehensive Treaty for regulating resource activities was concluded; (2) that Article 11 established guiding principles for the negotiation of such a successor Treaty which were antithetical to the commercial development of outer space and lunar resources by private enterprise; and (3) that the Agreement would thereby give other countries political control over the permissibility, timing and direction of expanding commercial uses of outer space.

It is very relevant that the negotiations for the Moon Treaty were concluded, and the debate over U.S. acceptance took place, in the context of a similar international and internal U.S. debate concerning the acceptability of the international seabed regime then being negotiated at the Third UN Law of the Sea (LOS) Conference. In particular, the phrase "common heritage of mankind" and proposals for an "international regime" in Article 11 inevitably brought to mind the same phrase which had figured prominently in the UNCLOS negotiations. Thus, opponents of ratification raised the spectre that the type of regime contemplated in Article 11 would mirror the highly controversial seabed regime contemplated by and embodied in Part XI of the LOS Treaty. In 1982 the Reagan Administration rejected the LOS Treaty on the ground that the proposed international seabed regime would both hamper effective development of seabed mineral resources and be antithetical to free enterprise principles strongly held by the U.S. Consequently, it is not surprising that the same U.S. administration considered the Moon Agreement also politically unacceptable and has since shown little interest in its ratification. Many other states have not ratified, perhaps also because of the ideological and other debate surrounding negotiation of the LOS Treaty or perhaps simply because the U.S. and other major space powers have not yet done so. However, for our purposes, it is worth examining in more detail what Article 11 and some of the other provisions appear to mean, drawing in particular on the 1980 Senate Commerce Committee Hearings on the Moon Agreement and on the Report of the Space Law Committee of the International Law Association at its sixtieth conference (Montreal 1982).

One question concerns the interpretation of Article 11(1), which provides that "the Moon and its natural resources are the common heritage of mankind." Opponents of the Agreement claim that, as a result of the UNCLOS III negotiations and LOS Treaty, the phrase "common heritage of mankind (which is specifically embodied in Article 136 of the LOS Treaty) has taken on a fixed meaning implying that such "common heritage" resources are not subject to direct national or private exploitation, but can only be legally developed and appropriated under the aegis and supervision of an international organization or regime controlled by a majority of nations--which, in effect, would be dominated by developing nations or the "group of 77." Thus, in this view the phrase in practice contemplates a moratorium on lunar exploitation--particularly exploration by national or private enterprises--pending the establishment of an international resource regime closely resembling the seabed regime established by Part XI of the LOS Treaty.

The contrary viewpoint, persuasively presented in the 1980 Hearings, is that the concept of "common heritage" has never had any fixed meaning. As used and accepted by the U.S. and developed states, it has only reflected very broad principles of justice and equity rather than any particular economic or political ideology--particularly one opposed to free enterprise. The scholarly literature suggests that, while the "common heritage" concept is uncertain in content and has not attained the status of customary law, it appears to express the following kinds of general ideas: (1) an area not subject to appropriation; (2) some kind of shared management responsibility; (3) some kind of arrangement for sharing of economic benefits; (4) use of the area only for peaceful purposes; (5) free and open scientific research and sharing of the results of such research; and (6) concern for the protection of environmental interests. Moreover, to the extent that the "common heritage" concept is interpreted by some nations as suggesting that resources cannot be exploited except under an international authority controlled by developing nations, the U.S. and many other countries have persistently objected to and not accepted the principle. Finally, the negotiating history of the Moon Treaty clearly demonstrates that the countries negotiating the agreement in COPUOS intended the "common heritage" principle to have its own separate meaning in the Moon agreement rather than having the same meaning as in the LOS Treaty. This interpretation, insisted upon by the Soviet Union in particular, is expressly reflected in the final clause of Article 11(1) which makes it clear that the "common heritage" concept "finds it expression in this Agreement," (rather than in any other agreement), and, in particular, in paragraph 5 of Article 11, which expressly contemplates a separate negotiation to establish a mineral resource regime of a very general and unspecified character. Consequently, the parties are free, if and when they eventually negotiate a mineral resources regime under Article 11(5) and 18, to devise a Moon regime of whatever nature they wish, subject only to the very broad criteria of Article 11(7). This regime can, and presumably will be completely different from the LOS seabed regime. Moreover, it is clear that, in any such further negotiation under Articles 11(5) and 18, any State Party which disagrees with the type of regime negotiated can refuse to agree to it and will not be legally bound.

A second question is whether the Agreement establishes a moratorium on or precludes the conduct of mineral resource activities by states, or by private enterprises under state sponsorship, pending the establishment of any international regime negotiated under Article 11(5). There appears to be nothing in the Agreement that suggests any such limitation on states in this respect, except as they might in the future expressly agree to such a moratorium in the context of negotiating the international regime contemplated by Article 11(5) or otherwise. Moreover, article 11(3) makes it clear that it is only natural resources "in place" that are not subject to potential property or ownership rights. It is clear from the negotiating history that the phrase "in place" was specifically proposed by the U.S., and was accepted by the other nations present, as a recognition that the Agreement did not imply any moratorium, and that mineral resource exploitation by States Parties or private entities was not precluded pending the establishment of any international regime. While the provisions of Article 6(2) are somewhat ambiguous in this respect--in that the express provision of a right to collect and remove mineral samples for scientific investigation might carry the negative implication that they cannot properly be removed for other purposes, the negotiating history seems to establish that the intent of the parties, as more strongly indicated in Article 11(3), was otherwise.

It may be noted that there was again, some ambiguity in the last sentence of Article 6(2) as to whether States Parties may also use mineral and other substances of the Moon in quantities appropriate for the support of their missions, not only in connection with "carrying out scientific investigations," as stated in the Article, but also in connection with other broader or resource-related activities--a consideration of some significance in connection with proposed He3 activities. As far as we have been able to determine, this language was not intended to be deliberately restrictive, and it was not the intent of the parties to preclude a broader use of lunar resources for support of even resource-related lunar stations or activities.

A third question is whether the Agreement in any way precludes private enterprise from a role in the eventual exploitation of lunar resources. Again, the negotiating history clearly supports the view that the U.S. was successful in preserving such rights. Article 11(3) and 14 in particular expressly contemplate a role for nongovernmental entities or natural persons. More broadly, nothing in Article 11 requires that any international regime eventually negotiated be of a nature which precludes a role for private enterprise or that such a regime take any particular form, such as employing majority-voting or other decisional principles. In fact, neither the Agreement nor its negotiating history suggest any definitions or particular meaning of the phrase "international regime." Moreover, as indicated, even if such a restrictive international regime was negotiated, no State Party would be obliged to accept it. While Article 7(d) establishes as one criteria of such a regime "equitable sharing by all States Parties in the benefits derived from these resources," the term "equitable" is not defined and the provision expressly includes "effort" as one relevant consideration. In the opinion of most commentators, "equitable" in this context cannot be considered to mean "equal"; while there appears to be some obligation to provide some share of benefits to the international community, there is no definition of what the "benefits" to be shared are, and no specific obligation as to how much must be shared or in what form. Clearly, there must be some at least token contribution to the "international community," but beyond that the obligation involved is extremely vague.

What, then, is the overall effect of the Moon Agreement on the law applicable to the exploitation of lunar resources? As indicated, the Agreement is not in itself legally binding on the U.S., nor indeed on most major "space powers" or other states, since they have not ratified it and are not Parties. Moreover, the Agreement should probably be given little weight otherwise, since, in contrast to other "space law" agreements which have achieved very wide ratification, it has over a considerable period gained few adherents, none of which are significant "space powers."

But this conclusion could be too cavalier. First, as indicated, the Agreement reiterates a number of principles and obligations already contained in and binding on the U.S. and many other states under the Outer Space Treaty. Indeed, some additional language in the Moon Agreement can be argued to be simply a spelling out of obligations implicit in the Outer Space Treaty--e.g. jurisdictional, environmental, and dispute-settlement principles, or even as an agreed interpretation by the most-concerned parties, through their participation in the negotiations in COPUOS, as to the meaning of those provisions. Second, the Agreement is a reflection of a long and careful negotiation and process of accommodation between the states in COPUOS primarily concerned with outer space and lunar activities; it represents their collective or consensus judgments and conclusions as to the most sensible and viable rules for the conduct and rational regulation of resource and other activities on the Moon. As such, the agreement is likely to have some impact on developing customary law and cannot, as a practical matter, be ignored. In particular, the provisions regarding the establishment of stations, conduct of scientific research, concern for environmental protection, obligations of noninterference and notice and consultation, liability and so forth could be in the process of emerging as obligatory rules of lunar law.

The effect of Article 11 or lunar resource exploitation is, of course, more problematic. The prohibition on national or private claims to portions of the surface or subsurface of the Moon, or to resources in place, would appear to do no more than reaffirm and spell out similar previously existing prohibitions already binding on the U.S. and other states under the Outer Space Treaty. However, the absence of any prohibition in the Agreement on States or private enterprises exploiting and acquiring ownership of lunar minerals, and the specific recognition of the legitimacy of such activities in the Agreement, would appear to reaffirm the like absence of any such prohibition in the Treaty. During the 1980 Hearing, the then Legal Adviser of the State Department, Roberts Owen, concluded on this point that: "... pending a Moon Conference in 15 or 30 years--and whether or not the United States becomes a party to the Moon Treaty--American companies will have a continuing legal right to exploit the Moon's resources." This conclusion has generally been supported by leading experts--for example, in the deliberations and report of the Space Law Committee of the International Law Association at its 1982 Montreal meeting--and in the relevant literature.

The commitment in the agreement to some type of "common heritage" principle, and to at least attempt the negotiation of an appropriate but undefined "international regime" for the exploitation of lunar resources at such time as exploitation is about to be feasible, is, of course, only binding upon the Parties to the Agreement. Moreover, what "international regime" means--its nature, structure, scope and procedures, the way any benefits will be allocated and whether it will be a system of rules and regulations or also include organizational arrangements--remains open. The negotiating history suggests an appreciation of the need for flexibility in this respect to allow for technological and other developments.

One important question left open in the Moon Agreement is the present nature and content of the environmental obligations stated in very general terms in Article 7, particularly as they may relate to lunar resource regime agreed upon pursuant to Article 11 [5]. Should the purpose of such environmental regulation be primarily preservation, conservation or protection consistent with reasonable development? Should the Moon, for scientific or aesthetic reasons, be kept in a pristine and unchanged condition--an objective possibly incompatible with resource exploitation? Should temporary but not permanent disturbances, such as might be involved in He3 mining, be allowed? Clearly, some answers to these questions should be developed early in the process of planning for a mineral resume regime--for, unless reasonable activities are allowed permitting exploitation at an affordable cost, development will be unlikely.

It seems likely, however, that the nations involved in lunar activities or contemplating lunar resource exploitation will eventually wish to seek some type of legal arrangement or agreed mineral resource regime to regulate such activities, whether through the modality of the Moon Agreement itself or otherwise. Indeed, each of the purposes stated for the regime in Article 11(7) of the Treaty are generally consonant with U.S. policy. Consequently, even if Article 11 is not now part of lunar law, it will necessarily constitute a precedent and set the context in which further discussions of these matters are likely to proceed.

V.E.3 INTELSAT (1964) and INMARSAT (1976)

The experience of INTELSAT and INMARSAT, while it does not purport to establish any rules directly applicable to lunar resource activities, may be suggestive as to the possible structuring of innovative arrangements for the exploitation or management of such resources.

On August 20, 1964, an Agreement Establishing Interim Arrangements for a Global Communication System was signed by the U.S. and ten other nations. It established the International Telecommunications Satellite Consortium (INTELSAT). INTELSAT in turn acquired the international communications satellite system created by COMSAT, a private U.S. corporation created by Congress for the purpose of planning and constructing such a telecommunications system. COMSAT became the U.S. representative to INTELSAT and the manager of the system, as well as the exclusive lessor to U.S. domestic common carriers of capacity in INTELSAT facilities. Most of the other parties to INTELSAT are represented either by their governments or by publicly controlled postal or other telecommunications organizations directly responsible to their governments. In 1971, the parties concluded a further set of Definitive

Agreements Relating to the International Telecommunication Satellite Organization "INTELSAT" which resulted in some change in the way it operated, including a shift from the role of COMSAT as manager of operations to a different procurement policy under the direction of a Director General. Over 110 states are now parties to INTELSAT.

INTELSAT was recently reported to have 16 satellites in orbit that serve 173 countries through more than 1000 satellite paths connecting almost 400 earth station antennae. INTELSAT carries two-thirds of the global transmissions, more than 360 two-way business service circuits, and most of the transoceanic telecommunications traffic.

The most relevant and interesting aspects of INTELSAT for our purposes can be described as follows:

- The agreement applies only to the "space segment" of INTELSAT, defined to include the telecommunications satellites themselves and related operating facilities; the earth stations which utilize and access the satellites are owned and operated by participating national entities.
- The objective of INTELSAT is the provision, on a commercial nondiscriminatory basis, of a space segment for international public telecommunications services.
- Membership in INTELSAT is open to the government of any state which is a member of the International Telecommunications Union, but it is intended that access to the system be available to all nations of the world or an indirect sharing of the benefits of this space.
- Investment and use are correlated, INTELSAT members participate by way of investment shares which are determined by the percentage of utilization of the INTELSAT space segment; that is, substantial users, such as the U.S., contribute more investment and have more shares.
- The organizational structure of INTELSAT includes an Assembly of Parties, a Board of Governors, and a meeting of signatories. Voting on the Board is in principle in proportion to the part of the investment share each member represents, but no governor may cast more than 40% of the total votes. Moreover, decisions or substantive matters require either (a) support of at least four governors representing at least two-thirds of the investment shares, or (b) the support of all but three governors, regardless of the total investment share they represent.
- INTELSAT has juridical personality and can conclude agreements, acquire and dispose of property, and be a party to legal proceedings.
- The pricing structure mandated by the INTELSAT agreements establishes a nondiscriminating pricing system reportedly designed to subsidize "thin" use by the third world and developing countries with "heavy" use by the industrialized nations, thus providing additional direct sharing of the benefits of space communications technology.

Similarly, in 1976, the need for an effective maritime communication system to deal with problems of rapidly growing maritime commerce and consequent danger of accidents, led to the negotiation, under the auspices of the International Maritime Organization, of a Convention on the International Maritime Satellite System, to which over 45 states are now parties.

The Memorandum of Understanding between NASA and European Space Agency, which is the only MOU presently available to us, provides a more detailed description of the objectives, nature and elements of the Space Station; access to and use of the Station; major program target milestones; respective responsibilities; management aspects of the program related respectively to design and development and to operations and utilization; operations cost responsibilities; safety; space station crew; transportation, communications and other non-space station facilities; advanced development program; space station evolution; financial arrangement; public information; and consultation and settlement of disputes. The MOU does not add to the criminal jurisdiction provisions of the principal agreement.

The Space Station Agreement is interesting in that it illustrates the possibility of, and provides a precedent for, multilateral cooperation by states having the interest as well as the technical and financial capacity to join in developing a very complex, expensive space project. It is understood that such a project will require their long-run and evolving cooperation and continual adjustment. It demonstrates in particular the possibility of, and certain procedures and mechanisms for, ongoing financial, policy and technical collaboration.

However, it is not clear from the Agreement itself how, if at all, the research results or other benefits derived from the operation of the various elements of the Space Station are to be shared, or whether the Agreement acknowledges any broader international responsibility in this respect; we would wish to research further as to the intent of the parties in their negotiations. Moreover, since the Space Station will be primarily an orbiting laboratory and platform, it does not in itself appear to raise, in the near term, the more complex issues of resource appropriation or sharing involved in lunar resource exploitation.

V.F <u>Other Treaties and Customary International Law</u>

As the Outer Space Treaty and Moon Agreement make clear, nations continue to be bound in their activities and relations in outer space or on celestial bodies, including the Moon, by the international agreements and customary international law principles otherwise binding upon them in their terrestrial relations.

V.F.1 <u>Principles of Environmental Protection</u>

While international environmental law is still in an early stage of development, it can be argued to provide at least some broad environmental norms relevant to mineral resource or other activities on the Moon, even apart from similar obligations reflected in the Outer Space Principles or Moon Treaty. Thus, it is now a widely held view that general international law incorporates the broad obligation stated in Principle 21 of the 1972 Stockholm Declaration on the Human Environment, which provides that:

> States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction, or control, do not cause damage to the environment of other states or of areas beyond the limits of national jurisdictions.

Since Stockholm the substance of Principle 21 has been recited and referred to in a great number of international agreements, resolutions and other international instruments, including Article 30 of the U.N. General Assembly 1974 Charter of Economic Rights and Duties of States, and, as indicated, the Antarctic Treaty, Antarctic Mineral Resources Convention, the Law of the Sea Convention and many other instruments specifically directed at pollution of the oceans, and a growing variety of other environmental treaties.

Section 601 of the authoritative, recently revised, Restatement of the Foreign Relations Law of the United States (1988) takes the position that:

> A state is obligated to take such measures as may be necessary, to the extent practicable under the circumstances, to ensure that activities within its jurisdiction or control
>
> (a) conform to generally accepted international rules and standards for the prevention, reduction, and control of injury to the environment of another state or of areas beyond the limits of national jurisdiction; and
>
> (b) are conducted so as not to cause significant injury to the environment of another state or of areas beyond the limits of national jurisdiction.

Certain other broad international environmental norms and norms of equitable utilization are arguably also applicable to the special situation of shared natural resources. For example, Article III of the 1974 Charter of Economic Rights and Duties of States provides that:

> In the exploitation of natural resources shared by two or more countries, each state must cooperate on the basis of a system of information and prior consultation in order to achieve optimum use of such resources without causing damage to the legitimate interests of others.

More specifically, the Draft Principles of Conduct in the Field of the Environment for the Guidance of States in the Conservation and Harmonious Utilization of Natural Resources Stated by Two or More States, approved by the Governing Council of the U.N. Environmental Program (UNEP) in 1978, provides, inter alia, that

> Principle 1
>
> It is necessary for States to cooperate in the field of the environment concerning the conservation and harmonious utilization of natural resources shared by two or more States. Accordingly, it is necessary that, consistent with the concept of equitable utilization of shared natural resources, States cooperate with a view to controlling, preventing, reducing or eliminating adverse environmental effects which may result from the utilization of such resources. Such cooperation is to take place on an equal footing and taking into account the sovereignty, rights and interests of the States concerned.

Principle 2

In order to ensure effective international cooperation in the field of the environment concerning the conservation and harmonious utilization of natural resources shared by two or more States, the States sharing such natural resources should endeavor to conclude bilateral or multilateral agreements between or among themselves in order to secure specific regulation of their conduct in this respect, applying as necessary the present principles in a legally binding manner or should endeavor to enter into other arrangements. States should consider the establishment of institutional structures, such as joint international commissions, for consultations on environmental problems relating to the protection and use of shared natural resources.

Principle 3

1. States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.
2. The principles set forth in paragraph 1, as well as the other principles contained in this document, apply to shared natural resources.
3. Accordingly, it is necessary for each State to avoid the maximum extent possible and to reduce to the minimum extent possible the adverse environmental effects beyond its jurisdiction of the utilization of a shared natural resource so as to protect the environment, in particular when such utilization might:

   (a) cause damage to the environment which could have repercussions on the utilization of the resource by another sharing State;
   (b) threaten the conservation of a shared renewable resource;
   (c) endanger the health of the population of another State.

Without prejudice to the generality of the above principle, it should be interpreted, taking into account where appropriate, the practical capabilities of States sharing the natural resource.

Principle 4

States should make environmental assessments before engaging in any activity with respect to a shared natural resource which may create a risk of significantly affecting the environment of another State or States sharing that resource.

Principle 5

States sharing a natural resource should, to the extent practicable, exchange information and engage in consultations on a regular basis on its environmental aspects.

Similar principles of equitable utilization have developed and been applied in other contexts, such as situations involving international rivers and lakes and shared continental shelf hydrocarbon deposits. Clearly, this issue will have to be dealt with in any international regime related to lunar resource exploitation.

V.F.2 Other Treaty and Customary International Law Principles

The principles and obligations of the United Nations Charter prohibiting the aggressive use of force (Article 2(4)) and requiring members to seek to settle by peaceful means disputes the continuance of which might threaten international peace and security (Articles 2(3) and 33), continue to be applicable to states in their activities and interrelations on the Moon as on Earth. Similarly, other generally applicable bilateral or multilateral treaties otherwise binding upon particular states, and not specifically limited in their application to particular Terrestrial territories, and principles of customary international law such as those relating to the exercise of jurisdiction, respect for the obligations of treaties, and so forth, will continue to bind states with respect to their activities and interrelations on the Moon. This would include, in particular, the principle of customary international law that title to territory cannot be acquired except through measures of effective occupation--a principle which has generally been held to preclude the acquisition of title (at least as against other states refusing to recognize such claims) over territory inherently incapable of supporting ordinary human occupation and settlement. Interesting questions could arise if and when the Moon becomes "capable" of supporting life in controlled settlements.

V.G Conclusion

Under currently existing international law, the U.S. cannot acquire under the Outer Space Treaty sovereignty over territory on the Moon or assert an exclusive claim to title over particular lunar resources in place. On the other hand, the U.S. could now legally mine and process lunar mineral resources and acquire property rights in the minerals removed. Moreover, it could conduct such mining activities itself or could permit such exploitation through private commercial enterprises or nongovernmental entities, so long as it sponsored and maintained supervision over their activities. The U.S. or private entities conducting such activities could probably retain at least the bulk of any proceeds of their operations, although there might be some obligation to set aside at least some portion for the benefit of other countries, and in particular developing countries.

The U.S. could legally establish stations, installations and facilities in connection with lunar activities, could exercise jurisdiction over such stations and personnel, and could probably use lunar resources as necessary for the maintenance or support of such stations or activities.

In conducting such activities, the U.S., or private enterprises under its sponsorship, would have obligations not to interfere with the activities of other states or access to or use by other states of significant areas of the Moon; not to significantly damage the lunar environment; to permit inspection of its stations and facilities; to provide at least nonproprietary information to the UN and other states and scientific organizations; to consult with other states as to any problems which might arise; and to be accountable for any injury or harm caused by it or entities under its sponsorship.

The permissive character of present international law in this respect is due in large part to its present undeveloped, fragmentary and uncertain state. It seems highly unlikely, however, that, over the long run, this situation can continue without a risk of significant international friction and controversy. The U.S. itself, for several reasons, could find it necessary and in its interest to establish some kind of acceptable international regulatory framework. First, it cannot be assumed that other states with the capability to conduct activities and exploit resources on the Moon will passively tolerate unilateral and unregulated U.S. resource-related activities on the Moon. Second, there seems little prospect that private enterprises will wish to make the enormous investment required for the development of lunar resource programs without some assurance of stability, tenure, and the absence of international controversy or legal uncertainty respecting such programs.

Consequently, it seems in the U.S. national interest, as well as in the interest of commercial enterprises potentially concerned, that some kind of agreed international regime to govern lunar mineral resource exploitation and other activities be established. In considering the nature and structure of such a regime, states will rely heavily on past precedents and experience, seeking to adapt it to the unique lunar context.

We turn now to an examination of the issues and concepts which are likely to help shape such a regime.

VI. UNIQUE ASPECTS OF HELIUM-3 AS A RESOURCE

The production, marketing, and sale of lunar helium-3 presents a number of unique or special aspects relative to other national or international activities. These can be examined in the context of existing or proposed activities related to the Earth surface, Earth orbit, lunar surface, Mars orbit, and Mars surface.

VI.A Legal and Political Activities on Earth

While the various legal precedents discussed in Part V--terrestrial mining law, the Antarctic Treaty and Law of the Sea Convention, the INTELSAT and INMARSAT Agreements and so forth--are useful and suggestive, there are differences between these experiences and the situation of lunar resource exploitation. That is, we will have to exercise some care deciding which precedents are really most relevant and useful. These distinctions include the following:

1. Time Dimension. The legal regimes previously discussed have developed and are being applied in the context of the present global constellation of political and economic power and normative concepts. There are certain to be very significant changes in these respects over the next 30 years.

2. Availability of the Resources. We know that there are manganese nodules on the seabed and the technology presently exists to get them. But whether or when it will be economic to exploit them is now very uncertain. Perhaps in part because these issues are not of immediate economic importance, ideological issues involved in the promulgation of a seabed regime have become very prominent. With regard to the Antarctic, the presence of significant mineral resources of economic value is still very uncertain, and it is very unlikely in the near future that exploitation will be feasible. Consequently, it is not surprising that the Antarctic Treaty parties, in shaping a mineral regime, have been primarily concerned with avoiding the conflicts of principle that the issue of exploitation might raise, and of controlling environmental risks from unregulated prospecting and exploration, rather than in establishing a detailed regulatory regime or deciding now how to allocate and share significant resources or profits. In the case of He3 on the Moon, on the other hand, a very significant resource is there, and, if technology and development proceed as it could, it could be available for the next generation.

3. Pre-existing Legal Framework. The Antarctic Treaty developed primarily as a means of avoiding disputes and conflict arising from a very tangled legal situation in which there were strong differences between important nations as to the validity of territorial claims and the lack of a compulsory mechanism for resolving these disputes. Similarly, the Law of the Sea Convention developed in part out of Developing Countries claims to seabed resources which developed nations regarded as already available for exploitation and appropriation under traditional and long-existing freedom of the sea principles. The situation regarding lunar resources is somewhat different in that it has been clear from early in the "space age" that territorial claims on the Moon were invalid, and that there was at least some legitimate stake by the international community in the sharing of space resources.

4. Public Perceptions. Emotional attitudes by people of all nations towards developments on the Moon may well be different from attitudes towards the seabed and Antarctica. It is arguable that, although the Moon is inaccessible and remote, it is much more a part of everyone's life than the seabed or Antarctica; we all can "see it" most nights and have done so all of our lives; it is constantly with us. Consequently, one might encounter a very strong resistance by some to any prospect that the Moon will either become, in effect, "one nation's Moon" or that it will somehow be spoiled or desecrated. On the other hand, the extraordinary worldwide interest in Apollo explorations of the Moon and its potential "benefit for all mankind" suggests that prudent exploitations will have broad support.

5. Precedents. Historical precedents to He3 fusion worth further consideration beyond that possible in this study include the synergisn between nuclear fission commercialization and uranium availability, the relationship between financial incentives and the construction of transcontinental railroads, the pivotal invention of the steam engine and the coal-fueled industrial revolution, and the advance of silicon chip based computers and the refinement of silicon processing technology.

6. Political and Military Significance. The development of a mineral resource regime for the Moon is likely to have less immediate practical military or political significance than has been the case with the general development of the Antarctic and Law of Sea regimes, which are integral parts of the world's terrestrial political system. The objective of the Antarctic Treaty was primarily political--to prevent the Antarctic from becoming the source or scene of international political or military conflict. Similarly, the Law of the Sea negotiations were influenced in part by general military and political considerations (e.g. passage of warships through straits). In the case of the Moon, the principle that the Moon should not be used for military purposes is already firmly established, and decisions respecting the Moon are less likely to have direct imports on terrestrial politics or balances of power. Consequently, other types of considerations--primarily economic, scientific or environmental--are likely to have more influence and weight.

VI.B. Earth Surface Resource Activities

1. Access: He3 production on the Moon or other activities dependent on the success of lunar operations must assume that access to the Moon's surface will be intermittent as a rule rather than as the exception as is generally the case on Earth. Bases in Antarctica and other geographically or meteorologically remote areas on Earth present the best partial analogies to this aspect of lunar base activities.

2. Earth/Moon Synergism: The development of a helium-3 fusion power industry and a lunar helium-3 production capability must advance in parallel for either to be viable technologically or economically. This mutual dependence will grow as importing nations on Earth become dependent on lunar helium-3 and a growing lunar settlement becomes dependent on helium-3 exports to support itself as a self-governing political entity. Similarities exist between this synergistic relationship and the historical development of most new large scale resource-dependent industries, that

is, the technology for the development of resource utilization and the economical availability of the resource had to proceed on interdependent paths.

3. Energy Competition: The ultimate cost of helium-3 energy derived to potential consumers must either be competitive in price with other comparable energy sources or, if mandated by environmental considerations on Earth, that cost should not be so high as to prevent access by the less developed nations.

4. Financing: The initial requirements for capital to finance the development of lunar helium-3 resources will be larger than most terrestrial resource development projects, although these requirements should not beyond the imagination of those who financed the development of the petroleum resources of Prudhoe Bay and the North Sea, the transportation systems of the Panama and Suez Canals, and the American and Soviet Transcontinental railroads. It is possible to conceive of a sequence of related investment steps each of which will provide positive cash flow and return on investment.

5. Environment: The extremely low grade of the raw resource material for lunar helium-3 will require that very large areas of the lunar surface be mined. The comparable human activities on Earth are those associated with agriculture and harvesting of forest products. In the case of helium-3 mining, there will be nearly imperceptible and geologically temporary changes in (1) the chemistry of the surface materials down to a few meters depth (only the gaseous elements will be extracted), (2) the visual aspect (small impact craters will be removed as the material is processed and returned to the smoothed surface), and (3) the density of the surface material will be decreased (volume increased) due to the same processes. Because of a change in the reflective properties of the mined materials, at some point in the future the effects of these changes may become visible from Earth. Environmental tradeoffs should include recognition, however, that protection of the Earth's environment (e.g., acid rain, CO_2 greenhouse effect, mine runoff, etc.) is the principal justification for considering He3 fusion and lunar mining.

6. Volume: The high energy content of He3 relative to other fluid energy sources (natural gas and oil) eliminates the need for continuous shipment to points of use. As with nuclear fission fuel, intermittent transport (i.e., once a year) of He3 to fusion plants would be standard practice.

7. Robotics and Automation: Mining and extraction industries on Earth are commonly labor intensive. The high vacuum and wide thermal fluctuations on the lunar surface, as well as its initial remoteness from an available labor force, will put a premium on the use of robotics and automation in the performance of routine and repetitive tasks associated with helium-3 mining, extraction, and processing. New, complex, and intellectually demanding tasks will require human intervention on the Moon as they do on Earth.

8. Consumer Protection: In most situations on Earth, a free market system will ultimately guarantee that competitive forces develop that protect consumers from monopolistic price and supply control and that insure technological innovation and productivity enhancement. In the case of long-term lunar helium-3 mining, extraction, processing, and delivery, the initial cost of market entry by competitors to the first successful enterprise may be so high as to require specific national or international action to introduce competitive forces. Regulation of return on investment may be necessary as in the case of public utilities in the U.S, however, "construction work in progress" costs may be introduced into the rate base, and environmental credits or penalties may be some of the necessary financial practices required to smooth out cash flow and investment requirements.

VI.C Earth Orbit Industrial Activities

1. Tangible Resources: The natural resources of the Moon, including helium-3, must be considered tangible resources relative to the resources of Earth orbit which are high vacuum at high pumping rates, microgravity, and, for the most part, a meteorologically unrestricted view of the Earth, sun, and stars. Although all resources have the potential to be marketed to needy consumers, the resources of Earth orbit can only be used in orbit unlike the transportable resources of the Moon.

2. Political Status: In contrast to the potential for self-governing settlements on the Moon as a consequence of the economic and by-product potential of lunar helium-3, it is difficult to imagine, although not totally impossible, a self-governing orbital station.

VI.D Other Lunar Surface Resource and Scientific Activities

1. Self-Sufficiency: Helium-3 production and the by-products associated with that production have the potential to make lunar settlements self-sufficient, economically attractive, and self-governing relative to other suggested lunar surface activities.

2. Mining: The delivery of supplies of lunar helium-3 to economically viable fusion energy plants on Earth will require the processing (essentially in place) of very large volumes of material. The volume mined annually for each plant supplied is comparable to the largest terrestrial mining operations such as those that produce coal and industrial minerals (millions of tons per year) except that the large volume of lunar material is not "moved" any great distance (i.e., 1-2 meters). These volumes will be much greater than those mined to produce other potential lunar resources such as oxygen.

3. By-products: The initial extraction of helium-3 from lunar materials also extracts large quantities of by-products that have high potential value for use in other activities in space or on Mars. These by-products include hydrogen, oxygen, nitrogen, carbon dioxide, and water. Indeed, helium-3 may be used for space power and propulsion systems related to travel to and from Mars and to supply permanent lunar and martian settlements.

VI.E Mars Orbit Resource Activities

1. Self-Sufficiency: The potential for economic self-sufficiency through helium-3 production on the Moon is significantly greater than such potential for stations in Mars orbit where the principal tangible resource appears to be water (from Phobos) that could be exported for use elsewhere in space or on Mars. Although Phobian water should be considered in future exploration and settlement strategies in the Solar System, it may not be able to compete with water derived as a by-product from lunar helium-3 production.

VI.F Mars Surface Resource and Settlement Activities

1. Earth/Mars Synergism: It is difficult to imagine at this time that a direct economic synergism will develop between the Earth and settlements on Mars comparable to that which can be contemplated for the Earth and Moon as a consequence of helium-3 production and use. Strong indirect economic ties between the Earth and Mars may develop because of the export of by-products produced on the Moon as a result of helium-3 export to Earth.

2. Tangible Resources: The tangible resources of Mars, such as water, oxygen, hydrogen, carbon, and petroleum(?), will play a critical role in the development of self-sufficient Martian settlements and their eventual political independence, however, there are no known resources (other than pieces of Mars) that could provide economic returns for their export to Earth. In the long term, the Martian economy may develop tradable items but probably not in the time frame that lunar helium-3 could be in routine use.

VII. POSSIBLE FRAMEWORKS FOR U.S. CONSIDERATION

VII.A General Characteristics of an Acceptable Regime

Assuming that it is in the U.S. national interest to seek the establishment of some kind of international regime to govern the exploitation of lunar mineral resources, what should be the general characteristics of such a regime, or the criteria by which its acceptability should be measured? We would suggest the following:

1. Provision for the exploration and development of lunar resources by the U.S. The regime should permit the U.S. to conduct, without burdensome regulation or interference, the activities reasonably necessary to prospect for, explore, mine, process and either use or transport to earth lunar resources, and in particular He3. The regime must clearly provide for the acquiring of property rights in minerals removed from the Moon's surface or subsoil, the effective operation of and control over necessary stations or facilities, jurisdiction over necessary personnel, some measure of exclusivity over areas subject to resource activities, and some measure of privacy over proprietary information. In particular, the regime must ensure the retention by the U.S. of reasonable proceeds or profits commensurate with the effort involved and sufficient to warrant the level of investment involved.

2. A role for private enterprise. Any regime should encourage private enterprise to play a significant role in exploration, development, and use of lunar resources, subject to appropriate and reasonable regulation. This means that private enterprise must have assurance of security of tenure during the life of mining operations and must have the right to retain profits from resource development and to transfer returned capital and profits to Earth. Private enterprise must also have assurance of reasonable taxation and reasonable environmental and other regulation. Environmental regulations should be designed and used solely to minimize impact of mining operations on the environment, to a degree consistent with economic viability of the operations. The permitting process should be simple, direct, and prompt. Poorly designed, unrealistic regulations, and tedious administrative procedures could be serious obstacles to development of lunar resources.

3. Management structure. The regime should provide a national or international management structure for helium-3 production, marketing, and sales that permits timely decisions, within general guidelines, on all aspects of operational management.

4. Consistency with international law. The regime should be consistent with existing U.S. obligations under the Outer Space Treaty, the U.N. Charter, other international instruments and customary international law. This includes the obligation not to claim title to appropriate territory on the Moon, and the obligation to respect the right of other states to conduct activities there and to conduct any activities with due respect for environmental concerns.

5. Prohibition of military activities. The regime should prohibit exploitation of space for military purposes or for other activities adverse to U.S. interests.

6. Encouragement of international cooperation. The regime should encourage cooperation rather than competition among states conducting activities on the Moon, including openness of access and reasonable exchanges of information, mutual assistance in situations of need, and joint activities when appropriate.

7. Recognition of broader international community concerns. The regime should contain provisions recognizing that the international community as a whole has legitimate interests in the exploration and use of the Moon and its resources. All states should have the right to conduct activities on the Moon without discrimination. The regime should recognize that the international community should share in the benefits of lunar exploitation. However, any wider sharing of benefits must be consistent with the primary right of the states and private enterprises actually carrying out mineral resource activities to a fair profit and return for their investment and effort. Otherwise, resource development will be significantly delayed or will not occur at all.

8. Obligations of nations to the international community. The regime should require that all states conducting activities on the Moon must meet their obligations to the broader international community and to future generations by ensuring that their activities do not cause significant environmental or other damage and provide a net environmental benefit to humankind.

9. Dispute-settlement procedures. The regime should contain provisions for the avoidance and peaceful resolution of disputes, including obligations requiring prior notification of actions likely to affect other states and consultation if problems, difficulties, or controversies arise. An acceptable code of criminal law and an appropriate mechanism for its enforcement also must exist.

10. Precedential considerations. The regime should avoid any precedent which might be unfavorable to other U.S. space or terrestrial interests or objectives, or contrary to U.S. foreign policies and objectives. In particular, the regime should not be of a nature lending support to proposals for direct U.N. ownership of particular mineral resources or detailed regulatory control of mineral resource activities, or to arrangements which would subject the mining activities of the U.S. or its enterprises to arbitrary control by developing nation majorities.

11. Self-determination. The regime should provide the opportunity for a peaceful transition to self-determination for lunar base settlers at a reasonable level of population, political power, and economic viability.

VII.B Can -- And Should -- The U.S. "Go It Alone"?

The U.S. technologically and financially probably is in a position to seek unilaterally to exploit lunar resources, including He3, and to develop an He3-based fusion energy program in the U.S. or globally. There does not appear at present to be any moratorium or legal barrier to the U.S. engaging in lunar mining subject to the general limitations imposed by the Outer Space Treaty and other general international law. As a practical matter, no nation other than the Soviet Union is likely in the near future to be in a position to challenge such unilateral U.S. action, by force or otherwise. Unilateral action would permit the U.S. to develop an appropriate legal regime of its own, consistent with its own ideology and concepts and designed to its own needs, rather than having to reach compromises with other countries. There is a precedent for U.S. unilateral action of this kind, in an analogous resource-oriented context, in U.S. rejection of the 1982 U.N. Law of the Sea Convention Seabed mining regime, and Congressional adoption of the 1980 Deep Seabed Hard Minerals Act.

However, even if the U.S. can "go it alone," there are a number of arguments suggesting that it should not do so. These include the following:

1. Even if the Outer Space Treaty and existing international law do not establish any legal moratorium on unilateral exploitation of lunar resources, they are implicit in the obligation of international cooperation and the avoidance of activities which might give rise to discord or disputes. Other things equal, the U.S. is generally committed to pursue cooperative rather than unilateral policies in its activities in space. Moreover, a sizeable fraction of the U.S. public could be expected to be generally more approving and supportive of cooperative rather than unilateral, potentially controversial, programs and actions.

2. Whatever may be the proper interpretation of existing law, unilateral exploitation of lunar resources by the U.S., particularly for the purpose of securing minerals such as He3 of immense value in the production of terrestrial energy, will likely be strongly objected to by some other nations and groups on Earth. Conceivably, such nations or groups could seek legal recourse in national or international courts or take other retaliatory or disruptive actions directed at a unilateral U.S. effort or program. Any potential objections of this sort would create uncertainties possibly affecting the long term stability and security of investment and, thus, the willingness of investors to make necessary commitments. Moreover, the development of a global market for He3 presupposes some type of technological and distribution cooperation terrestrially; controversy or discord as to the lunar mining of He3 could carry over to and obstruct such terrestrial arrangements.

3. In the long run, if countries other than the U.S. (such as the Soviet Union) also engage in activities on the Moon, unilateral action by each of them will make little sense. Ultimately, there will have to be at least some mechanisms to coordinate their activities and prevent them from interfering with each others' programs. If such coordination will ultimately be required, it might be easiest and most sensible to provide a regime early, before activities begin and while agreements may be simpler to reach.

4. In view of the enormous technological task and costs of conducting a lunar resource program, and especially a He3 fusion energy program, international cooperation and possibly a sharing of effort and costs may be desirable or essential. Indeed, it may be wasteful for countries to duplicate effort and expense on similar projects. International experience in analogous projects such as INTELSAT, INMARSAT and the Space Station suggest the possibilities and mutual advantages of such shared collective efforts.

5. International cooperation in fusion research (and He3 research) is already occurring under International Atomic Energy Agency (IAEA) auspices in the International Thermonuclear Experimental Reactor (ITER) project, which involves the U.S., Soviet Union, Europe, Japan and other countries. It could be inconsistent with the U.S. involvement in this project for the U.S. to now seek to "go it alone" with respect to the mining of a fuel that might be required for reactors developed through this cooperative effort.

For these reasons, we believe that, on balance, the U.S. should seek to establish a lunar resource regime through international agreement and cooperation rather than by unilateral action. However, we also believe it may be necessary for the U.S. to show a resolve to "go it alone" as a way of encouraging international cooperation.

VII.C Chronology of Relevant Work on Lunar Resources

In the late 1960's, the opening of accessibility to the Moon and ultimately to its resources generated a continuing literature on both the legal status of lunar resources and the possible technical uses of such resources. A briefly annotated overview of that literature helps to give some perspective on the evolution of legal and technical thought that underpins current considerations of the development and utilization of helium-3 from the Moon.

1968

Adams, T.R. (1968) The Outer Space Treaty: An interpretation in light of the no-sovereignty provision. Harvard J. Int. L., v. 9, p. 140-157.

Discussion of the foundations upon which extraterrestrial law rests and which are the legal considerations applicable to lunar resource development and utilization. Treats the issue of national sovereignty on the Moon and concludes that such sovereignty cannot be exercised legally.

Bhatt, S. (1968) Legal controls of exploration and use of the moon and celestial bodies. Indian J. Int. L., v. 8, p. 33-48.

Treats the issue of national sovereignty on the Moon and concludes that such sovereignty cannot be exercised legally.

1970

Apollo 11 Proceedings (1970) First Lunar Science Conference. Geochimica et Cosomchimica Acta, Supplement 1, 3 volumes.

Many investigators of the chemistry of the Apollo 11 samples noted the presence of elements that later analysis would show to be potential resources for use in space (oxygen, hydrogen, helium, nitrogen, carbon, and various metals). The presence of ilmenite, later to be a favored source material for oxygen, is uniformly noted in a large number of papers. Solar wind derived gases, such as hydrogen, nitrogen, carbon, and helium, were investigated in detail by many groups. Those original reports that would be of future significance to helium-3 as a resource are noted below:

Eberhardt, P., Geiss, J., Graf, H., Grogler, N., Krahenbuhl, U., Schwaller, H., Schwarzmuller, J., and Stetler, A. (1970) Trapped solar wind noble gases, exposure age and K/Ar-age in Apollo 11 lunar fine material.

Determined the abundance of helium and the He4/He3 ratio in lunar fine material (fine regolith) and noted that helium content is inversely proportional with grain size and directly correlated with the presence of ilmenite.

Heymann, D., and Yaniv, A. (1970) Inert gases in the fines from the Sea of Tranquillity.

Determined the abundance of helium-3 in lunar fine material as well as that of helium-4 and the He4/He3 ratio. Also noted that the helium content is inversely proportional to fragment size for most of the lithic fragments in the fines.

Kirsten, T., Muller, O., Steinbrunn, F., and Zahringer, J. (1970) Study of distribution and variations of rare gases in lunar material by a microprobe technique.

Investigated helium abundances in lunar fines, breccias, and rocks using a microprobe and also determined the He4/He3 ratio. Found that helium contents are highest in titanium-rich materials and lowest in calcium-rich materials.

Pepin, R.O., Nyquist, L.E., Phinney, D., and Black, D.C. (1970) Rare gases in Apollo 11 lunar material.

Performed stepwise heating experiments on lunar fines showing that about 90 percent of the helium-3 is released below 800°C.

1971

Kulebyakin, V. (1971) The moon and international law. International Affairs (Moscow), v. 9, p. 54-57.

Discussion of the foundations upon which extraterrestrial law rests and which are the legal considerations applicable to lunar resource development and utilization.

1972

Gorove, S. (1972) The concept of "common heritage of mankind": A political, moral or legal innovation. San Diego L. Rev., v. 9, p. 390-404.

Concludes that the "common heritage of mankind" concept is not yet a principle of international law and is of only limited relevance to the Moon's resources.

Lachs, M. (1972) The law of outer space. Sijthoff and Nordhoff, Rockville, 212 pp.

Discussion of the foundations upon which extraterrestrial law rests and which are the legal considerations applicable to lunar resource development and utilization.

1973

Kopal, V. (1973) The development of legal arrangements for the peaceful uses of the moon. Proc. 15th Colloq. L. Outer Space, p. 149-164.

Discussion of the foundations upon which extraterrestrial law rests and which are the legal considerations applicable to lunar resource development and utilization.

1974

Cocca, A.A. (1974) The principle of the "common heritage of all mankind" as applied to natural resources from outer space and celestial bodies. Proc. 16th Colloq. L. Outer Space, p. 174-176.

Considers the issue of "special consideration" for the "interests and needs of the developing countries" in the development of lunar resources.

Vassilovskaya, E.G. (1974) Legal problems of the exploration of the moon and other planets. Proc. 16th Colloq. L. Outer Space, p. 168-171.

Discusses the possible evolution of extraterrestrial law pertinent to lunar resources as new technologies are developed and further exploration is undertaken.

Dekanozov, R.V. (1975) Juridical nature of outer space including the moon and other planets. Proc. 17th Colloq. L. Outer Space, p. 200-207.

Treats the issue of national sovereignty on the Moon and concludes that such sovereignty cannot be exercised legally.

1976

Driggers, G.W. (1976) Some potential impacts of lunar oxygen availability on near-Earth space transportation (abstract). In Lunar Science VII, Special Session Abstracts, p. 26-34, LSI, Houston.

Early suggestion of the value of lunar derived oxygen for use in space transportation.

1977

Heymann, D. (1977) Physics and Chem. of the Earth, v. 10, pp. 45.

Abundance of helium in the lunar regolith is greater in the maria than in the highlands and appears to correlate with the abundance of ilmenite.

1978

Criswell, D.R. (1978) Extraterrestrial Materials Processing and Construction. Final Report, NASA CR-158870, NASA, Washington, 476 p. (Second report published in 1980).

Early proposal that the rocks and minerals of the Moon could be a source of oxygen for use in space.

Dekanozov, R.V. (1978) Juridical nature of outer space including the moon and other planets, Proc. 17th Colloq. L. Outer Space, p. 200-207.

Considers the issue of "special consideration" for the "interests and needs of the developing countries" in the development of lunar resources.

Matte, N.M. (1978) The draft treaty on the moon, eight years later. Ann. Air Space L., v. 3, p. 511-544.

Summarizes the general principles of extraterrestrial law that are established and are currently applicable to the Moon.

1979

Williams, R.J., and Erstfeld, T.E. (1979) High temperature electrolyte recovery of oxygen from gaseous effluents form the carbo-chlorination of lunar anorthite and the hydrogenation of ilmenite: A theoretical study. NASA TM-58214, NASA, Washington, 51p.

Early theoretical examination of the feasibility of extracting oxygen from lunar materials.

NASA (1979) Space Resources and Space Settlements. J. Billingham, W. Gilbreath, B. Gossett, and B. O'Leary, editors, NASA SP-428.

Compilation of many presentations dealing with the utilization of lunar resources, particularly oxygen for use in space, two of the more pertinent of which are cited below:

Rao, D.B., Chowdery, U.V., Erstfeld, T.E., Williams, R.J., and Change, Y.A. (1979) Extraction processes for the production of aluminum, titanium, iron, magnesium, and oxygen from nonterrestrial sources.

Williams, R.J., McKay, D.S., Giles, D., and Bunch, T.E. (1979) Mining and beneficiation of lunar ores.

Dula, A. (1979) Free enterprise and the proposed moon treaty. Houston J. Int. L., v. 3, 3-35.

Discusses the possible evolution of extraterrestrial law pertinent to lunar resources as new technologies are developed and further exploration is undertaken.

Kolosov, Y.M. (1979) Legal and political aspects of space exploration. International Affairs (Moscow), March 1979, p. 86-92.

Concludes that the "common heritage of mankind" concept is not yet a principle of international law and is of only limited relevance to the Moon's resources.

Menter, M. (1979) Commercial space activities under the moon treaty. Syracuse J. Int. L., and Comm., v. 7, p. 213-238.

Discussion of the foundations upon which extraterrestrial law rests and which are the legal considerations applicable to lunar resource development and utilization.

1980

Christol, C.Q. (1980) The common heritage of mankind provision in the 1979 agreement governing the activities of states on the moon and other celestial bodies. Int. Lawyer, v. 14, p. 429-465.

Considers the issue of "special consideration" for the "interests and needs of the developing countries" in the development of lunar resources.

Smith, D.D. (1980) The moon treaty and private enterprise. Astronaut and Aeronaut, v. 18, p. 62-63.

Considers the issue of "special consideration" for the "interests and needs of the developing countries" in the development of lunar resources.

1981

Dolman, A. (1981) Resources, Regimes, World Order. Pergamon, New York, 425 p.

Concludes that the Moon is currently regarded as legally immune from sovereign claim or territorial acquisition.

Galloway, E. (1981) Issues in implementing the agreement governing the activities of states of the moon and other celestial bodies. Proc. 23rd Colloq. L. Outer Space, p. 19-24.

Summarizes the general principles of extraterrestrial law that are established and are currently applicable to the Moon.

Williams, S. (1981) International law before and after the moon agreement. Int. Relations, v. 7, p. 1168-1193.

Treats the issue of national sovereignty on the Moon and concludes that such sovereignty cannot be exercised legally.

1982

Steurer, W.H. (1982) Extraterrestrial Materials Processing. NASA, JPL Publication 82-41, 123 p.

Initial report on a multi-year study on the processing of lunar materials for use in construction, shielding, propellants, semiconductors, and life support.

Christol, C.Q. (1982) The modern international law of outer space. Pergamon, New York, 945 p.

Discussion of the foundations upon which extraterrestrial law rests and which are the legal considerations applicable to lunar resource development and utilization. Treats the issue of national sovereignty on the Moon and concludes that such sovereignty cannot be exercised legally.

1983

Carroll, W.F. (1983) Research on the use of space resources. NASA, JPA Publication 83-86.

Reports research on extraterrestrial materials processing with emphasis on methods for extracting oxygen and metals from lunar oxides and on processes for mixed metal separation. Study also addressed possible uses of lunar materials other than helium-3.

Larschan, G., and **Brennan**, B. (1983) The common heritage of mankind principle in international law. Columbia J. Int. L., v. 21, p. 305-331.

Considers the issue of "special consideration" for the "interests and needs of the developing countries" in the development of lunar resources.

Menter, M. (1983) Peaceful uses of outer space and national security. Int. Lawyer, v. 17, p. 581-595.

Discusses the possible evolution of extraterrestrial law pertinent to lunar resources as new technologies are developed and further exploration is undertaken.

Smith, D.D., Paptkieviez, S., and Rathblatt, M. (1983) Legal implications of a permanent manned presence in space. W. Va. L. Rev., v. 854, p. 857-872.

Discusses the possible evolution of extraterrestrial law pertinent to lunar resources as new technologies are developed and further exploration is undertaken.

1985

Mendell, W.W. (1985) Lunar Bases and Space Activities of the 21st Century. LPI, Houston, 865 p.

Proceedings of the First Symposium by this name, sponsored in 1984 by NASA and the Lunar and Planetary Institute. This volume contains a large

number of technical papers pertinent to the development of lunar resources, including chapters entitled "Lunar Construction," "Lunar Materials and Processes," and "Oxygen: Prelude to Lunar Industrialization." This Symposium and preparations for it at the Los Alamos National Laboratories, led by Michael Duke of NASA and Paul Keaton of LANL, initiated a renewed interest on the part of NASA in the potential of lunar bases and lunar resources.

Joyner, C.C. and Schmitt, H.H. (1985) Extraterrestrial law and lunar bases: General legal principles and a particular regime proposal (INTERLUNE). In Lunar Bases and Space Activities of the 21st Century, W.W. Mendell, editor, LPI, Houston, p. 741-750.

This paper by Joyner and Schmitt consists of a summary and analysis of current treaties that impact on international activities in space and a formulation of a particular regime, called INTERLUNE, for the management of international facilities and operations in space. INTERLUNE is a concept closely allied with the existing management regimes embodied in INTELSAT and INMARSAT, that is, a user based representation of nations rather than a one nation, one vote representation.

Moore, A.L. (1985) Legal responses for lunar bases and space activities in the 21 st century. In Lunar Bases and Space Activities on the 21st Century, W.W. mendell, editor, LPI, Houston, p. 735-739.

Brief delineation of possible models for lunar base management. Concludes that, although there is no rule of law precluding profit or private enterprise from space, some form of international cooperation is required.

Smith, P.M. (1985) Lunar stations: prospects for international cooperation. In Lunar Bases and Space Activities of the 21st Century, W.W. Mendell, editor, LPI, Houston, p. 717-723.

Review of examples of terrestrial international cooperation in the context of lunar base and resource development. Concludes that any number of models may be applicable.

<u>1986</u>

LGO Science Workshop (1986) Contributions of a Lunar Geoscience Observer (LGO) Mission to Fundamental Questions in Lunar Science. Phillips, R., Workshop Chair, Southern Meth. Univ., Dallas, TX, 86 p.

The Workshop, during two sessions in 1985, included an analysis of the value of a lunar geoscience orbiting spacecraft to the search for resources such as metals, rare elements, ice, and indirectly hydrogen and oxygen.

National Commission on Space (1986) Pioneering the Space Frontier. Bantum, New York, 211 p.

The Commission, during hearings held in 1985, spent significant time examining the potential of lunar resources, concentrating its attention on raw soil (shielding and mass drivers), oxygen (propellant), raw glasses (construction), iron (manufacturing), silicon (solar cells), hydrogen (fuel and water), and other elements useful to space manufacturing and construction. Although not recognizing the energy potential of helium-3, the Commission specifically recommended:

> A continuing program to test, optimize, and demonstrate chemical engineering methods for separating materials found in space into pure elements suitable as raw materials for propellants and for manufacturing. Studies should also be carried out to allow choices to be made of the most cost-effective power sources for these processes at various locations in space and on selected bodies of the inner Solar System.

The Commission also deliberated on the issues of international cooperation and competition, making the following specific recommendations:

> Within these guidelines [...avoid ill-advised technology transfer...draw on the unique capabilities of each nation...coordinated parallel missions...], selective cooperation should be actively sought with the Soviet Union.
>
> Continued cooperative space ventures [should] be pursued vigorously with friendly developed countries, with due regard for reciprocity and the protection of U.S. commercial interests.
>
> The United States [should] creatively seek broad opportunities to apply appropriate space technologies to meet the needs of less developed countries.
>
> The United States [should] avoid accepting international arrangements that give broad jurisdiction over American activities in space to international bodies in which adversaries have undue influence or in which decisions will be made by majorities with little current competence in the space field. In addition, we recommend against U.S. support for any global organization that purports to regulate broadly the utilization of outer space.
>
> The United States [should] not become a party to the Moon Treaty [...the Treaty's provisions for the use of natural resources on other celestial bodies suggest a collectivized international regime analogous to the sea bed mining regime in the Law of the Sea Treaty. Such a regime could seriously inhibit American enterprise in space.]

Schmitt, H.H. (1986) Lunar base network activation scenario. In the Final Report, Lunar Power Systems, NASA-JSC Contract, NASA 9-17359.

Detailed day by day presentation of an activation scenario designed to create an operational lunar base network for resource production and scientific exploration.

Wittenberg, L.J., Santarius, J.F., and Kulcinski, G.L. (1986) Lunar source of He3 for commercial fusion power. Fusion Technology, v. 10, p. 167.

First recognition of the possible recovery of previously discovered He3 in the lunar regolith as a fuel for fusion power on Earth. Includes an analysis of the total energy budget for He3 production and delivery to Earth.

1987

Emmert, G.A., and Deng, B.Q. (1987) Ignition in near term D-He3 tokamak reactors. Presented at the 12th Symposium on Fusion Engineering, Oct. 12-16, 1987, Monterey, CA, UWFDM-740.

Determination that the prospects are good for utilizing currently planned fusion test reactors to achieve breakeven and ignition for D-He3 fusion.

Kulcinski, G.L., Sviatoslavsky, I.N., Emmert, G.A., Attaya, H., Santarius, J.F., Sawan, M.E., and Musicki, Z. (1987) The commercial potential of D-He3 fusion reactors. Presented at the 12th Symposium on Fusion Engineering, Oct. 12-16, 1987, Monterey, CA, UWFDM-745.

Detailed examination of the construction and operating cost of possible commercial tandem mirror He3 fusion reactors based on a comparison with analyses of other possible commercial fusion systems.

Kulcinski, G.L., and Schmitt, H.H. (1987) The moon: an abundant source of clean and safe fusion fuel for the 21st century. 11th International Scientific Forum on Fueling the 21st Century, October 1987, Moscow, USSR.

Review of the physics, resource, and economic issues and potential of He3 fusion on Earth and in space.

1988

Cameron, E.N. (1988) Mining for helium - site selection and evaluation. Second Symposium on Lunar Bases and Space Activities of the 21st Century, April 1988, Houston.

Develops the geological strategy for the delineation of areas economically favorable to mining for helium-3.

Crabb, T.M., and Jacobs, M.K. (1988) Synergism of He3 acquisition for a lunar base. Second Symposium on Lunar Bases and Space Activities of the 21st Century, April 1988, Houston.

Analyses the interrelationships between helium-3 development for terrestrial applications and the establishment of a lunar base.

Haskin, L.A. (1988) Water and cheese from the lunar desert: abundances and accessibility of H, N, and C on the moon. Second Symposium on Lunar Bases and Space Activities of the 21st Century, April 1988, Houston.

Examines the potential resource base for hydrogen, nitrogen, carbon, and other elements and the processes necessary to extract such resources from the lunar regolith.

NASA (1988) Lunar Helium-3 Fusion Power Workshop. April 25-26, 1988, Lewis Research Center, Cleveland, OH, NASA CF-10018.

Detailed examination by representatives of NASA, Department of Energy, industry, and academia of the feasibility of both helium-3 fusion power

systems and helium-3 lunar mining. General conclusion was that there are no obvious technical roadblocks to either.

Schmitt, H.H. (1988) Interlune: A management concept for lunar helium-3 extraction. Second Symposium on Lunar Bases and Space Activities of the 21st Century, April 1988, Houston.

Most recent formal discussion of the INTERLUNE concept, in this instance in the context of helium-3 mining on the Moon.

Schmitt, H.H. (1988) The real world and lunar base activation scenarios. Second Symposium on Lunar Bases and Space Activities of the 21st Century, April 1988, Houston.

Examines the operational principles to be considered in the establishment of a network of lunar bases designed for both resource extraction and scientific exploration.

Sviatoslavsky, I.N., Santarius, J.F., Wittenberg, L.J., Cameron, E.N., Crabb, T.N., and Jacobs, M.K. (1988) Mobile helium-3 mining system and its benefits toward lunar base self-sufficiency. Space 88 - Engineering, Construction, and Operation in Space Conference, August 1988.

Refined engineering analysis of a lunar He3 mining system and of the use of the by-products of He3 mining in the establishment of lunar base self-sufficiency.

Kulcinski, G.L., Emmert, G.A., Blanchard, J.P., El-Guebaly, L.A., Khater, H.Y., Santarius, J.F., Sawan, M.E., Sviatoslavsky, I.N., Wittenberg, L.J., and Witt, R.J. (1988) Apollo - an advanced fuel fusion power reactor for the 21st century. 8th Topical Meeting on the Technology of Fusion Energy, October 1988, Salt Lake City, UT.

Analysis of a tokamak fusion system that uses lunar He3 showing the environmental and economic advantages of such an energy supply.

VII.D <u>INTERLUNE Concept</u>

The most developed concept of a legal regime for the international management of activities related to a lunar base is the INTERLUNE concept introduced by Joyner and Schmitt [1]. It appears that this concept can be readily applied to a He3 fusion enterprise, and we have developed it further below. INTERLUNE is only one example, albeit an intriguing one, of how such an enterprise might be managed effectively and equitably by the international community while at the same time providing opportunities for free enterprise activities under its jurisdiction. It meets most, if not all, of the characteristics for an acceptable regime given in Section VII.A. However, we emphasize that there may be other equally valid concepts for lunar resource development, although none are as developed in the open literature.

VII.D.1 Background

International experience presently includes a successful model of a cooperative system for the management of high technology which could be applied to a helium-3 enterprise. This model system is INTELSAT (see V.E.3), a user-based management organization for the operation of international telecommunications satellites [2]. INTELSAT has conformed successfully to the legal, operational, and self-interest constraints that apply to international operations in space.

The political and technical management of a global communication satellite system, as manifested by the INTELSAT organization, is a unique space age entry into the international scene. It is an organization that developed because of a coincidence of new technology and obvious international need. To the credit of the United States, this coincidence was quickly noted by the U.S. which then guided the gradual trial-and-error development of INTELSAT, including a voluntary limitation to a minority voting position in its councils. To the credit of the INTELSAT organization, it has become an example of international cooperation that is not only remarkably successful but also utilitarian and profitable. INTELSAT is tied to the United Nations through its recognition of the regulatory functions of the International Telecommunications Union.

The INTELSAT model has already spawned one successful imitator, INMARSAT, which manages international maritime communication satellites and includes the Soviet Union and various Eastern Block nations as members. Modified versions of this model have been proposed for the management of international waterways [3], space-based antenna farms [4], and Mars Exploration [3]. Here, we examine the INTERLUNE proposal of Joyner and Schmitt [1] in the context of the management of the development of commercial helium-3 fusion on Earth and helium-3 production on the Moon.

It appears that the INTERLUNE concept would satisfy all the constraints of current space law as well as be consistent with the principles of free enterprise. The primary purpose of the proposed INTERLUNE organization could be to manage both the initial development of commercial helium-3 fusion power on Earth and the development and operation of helium-3 production facilities on the Moon. By-products of helium-3 production would, in turn support a self-sufficient lunar base that could provide international access to a variety of facilities, consumable commodities, and services. INTERLUNE would bring into the management of these enterprises those nations and other interests with the greatest motivations for insuring its successful implementation.

INTERLUNE is a concept of the space age and of the recognition that space resources are common resources of the spaceship Earth. INTERLUNE does not require that territorial sovereignty be given up in space; it does not require that free-enterprise opportunities be abandoned in space; it merely requires that sovereignty and opportunity be shared.

VII.D.2 Philosophical Basis of INTERLUNE

Technological advancements have produced a trend towards the realization of the legally undefined term "common heritage of mankind" in certain international resources. This trend is most apparent in negotiations regarding the resources of the seas and outer space. It indicates a general realization that nations have common interests in sharing benefits from the development and environmentally sound use of these resources. Increasingly, since the introduction of the "common heritage of mankind" discussion, nations have become concerned about the protection of the environmental heritage of humankind here on Earth. The provisions of the Antarctic Mineral Resource Convention, the international ozone agreement, and the rising interest in helium-3 fusion as an environmentally benign source of electricity demonstrate that the common heritage and the environmental heritage themes are inextricably intertwined in international consciousness.

Most nations now recognize that the Moon can become a common heritage resource for humankind as witnessed by the intense negotiations surrounding the Moon Treaty. It is not so widely recognized that the Moon will not be available to humankind without a workable management system and a nonconfrontational management environment as further witnessed by the current reluctance of most nations to sign that same treaty.

As envisioned by Joyner and Schmitt and viewed here in the context of the potential of helium-3 fusion, the resolution of issues related to space resources should be possible through an institutional arrangement, such as INTERLUNE, which would vest control of lunar resource production and distribution in an organization comprised of, first, nations who will actively participate in creating the necessary capabilities, second, other entities who are solely users or beneficiaries of such capabilities, and, third, investors, in the enterprise as a whole. Such nations and entities would be united by a common bond of policy and purpose which would be focused on both the technical and financial success of the enterprise.

There are four principal advantages of sharing sovereignty and opportunity under this concept:

First, the potentially disastrous discontent over which nation should exert control over lunar resource-related operations would be alleviated.

Second, the concept can provide institutionalized access and influence to all participants. Nations, customers, users, and investors with any degree of participation in INTERLUNE would have to be consulted, eliminating the possibility that small or temporarily small participants could be frozen out entirely.

Third, the operational objectives of a lunar base or settlement would be best met by this concept. The most important of these objectives are (1) assuring reliable supplies of helium-3 and other resources to terrestrial and space customers, (2) assuring access by all members to the base and its services, (3) assuring access to proprietary technologies, available material resources, and profits in proportion to a fair valuation of member participation, (4) assuring access to lunar scientific opportunities, (5) maintaining reasonable and uniform rate structures bearing a realistic relationship to the value derived from the use of the base, its resources, and spacecraft moving to and from the base, while also considering operating expenses and return on investment, (6) assuring administrative stability, (7) assuring effective maintenance and operation of facilities and services, and (8) assuring continued and environmentally sound expansion, improvement, and development of spacecraft, facilities, and services.

Finally, creation of an international organization of all nations, customers, users, and investors who wish to actively participate in the excitement of space pioneering and environmental protection on Earth cannot but help to improve the friendship and unity of purpose of nations and peoples on Earth.

VII.D.3 Management Structure

The conceptual advantages of a user-based international organization will only be realized if the actual institutional structure is designed to provide an equitable system under which the various interests can exert influence and control, as well as to provide for efficient and proper management.

Potentially, there are three distinct mechanisms by which nations, users and investors may be involved in INTERLUNE. The first mechanism relates to the research and development activities necessary to commercialize helium-3 fusion power on Earth. This mechanism draws to INTERLUNE research and development interests, investors, and potential customers for helium-3 on Earth. The second mechanism encompasses the creation and operation of a lunar base. It brings to the table those nations, entities, and investors that contribute directly and substantively to the activities required to establish the base and stabilize its initial operation. The third mechanism relates to the use and the terms and conditions for use of the base, its accessible resources, and the proprietary technologies required to establish it. This mechanism attracts those nations, users, and investors who contract with or invest in INTERLUNE in order to benefit from its activities.

The main functioning bodies within INTERLUNE would be the Assembly of Parties, the Board of Governors, the Board of Users and Investors, the Director General's Office, and a Judicial Tribunal (see Figure 11). The member nations of the Assembly of Parties would collectively exert policy authority over the major contributing nations, groups of smaller participating nations, and representatives of the Board of Users and Investors all of whom comprise the Board of Governors. The Board of Governors, in turn, would exert operational authority over the Director General, the operating arm of INTERLUNE. The Board of Users and Investors, working within the policy framework set down by the Assembly of Parties, would develop recommendations on operational and financial issues affecting their interests. These recommendations would be presented to the Board of Governors through the formal representatives of the Board of Users and Investors on that Board. The Judicial Tribunal would act as the final arbiter of internal disputes related to the legal interpretation of the INTERLUNE charter and general international law as well as the final court of appeals in internal criminal and civil matters.

The management objective of INTERLUNE would be the creation of a cost-effective helium-3 fusion power infrastructure, a lunar base, and a resource production and distribution system of high functional quality, safety, and reliability. These capabilities would be available on an open and nondiscriminatory basis to all peaceful customers, users, and investors. The internal structure and philosophy of INTERLUNE would not only provide for all participants to have representation in decisions affecting its activities, but would also insure effective and responsible management.

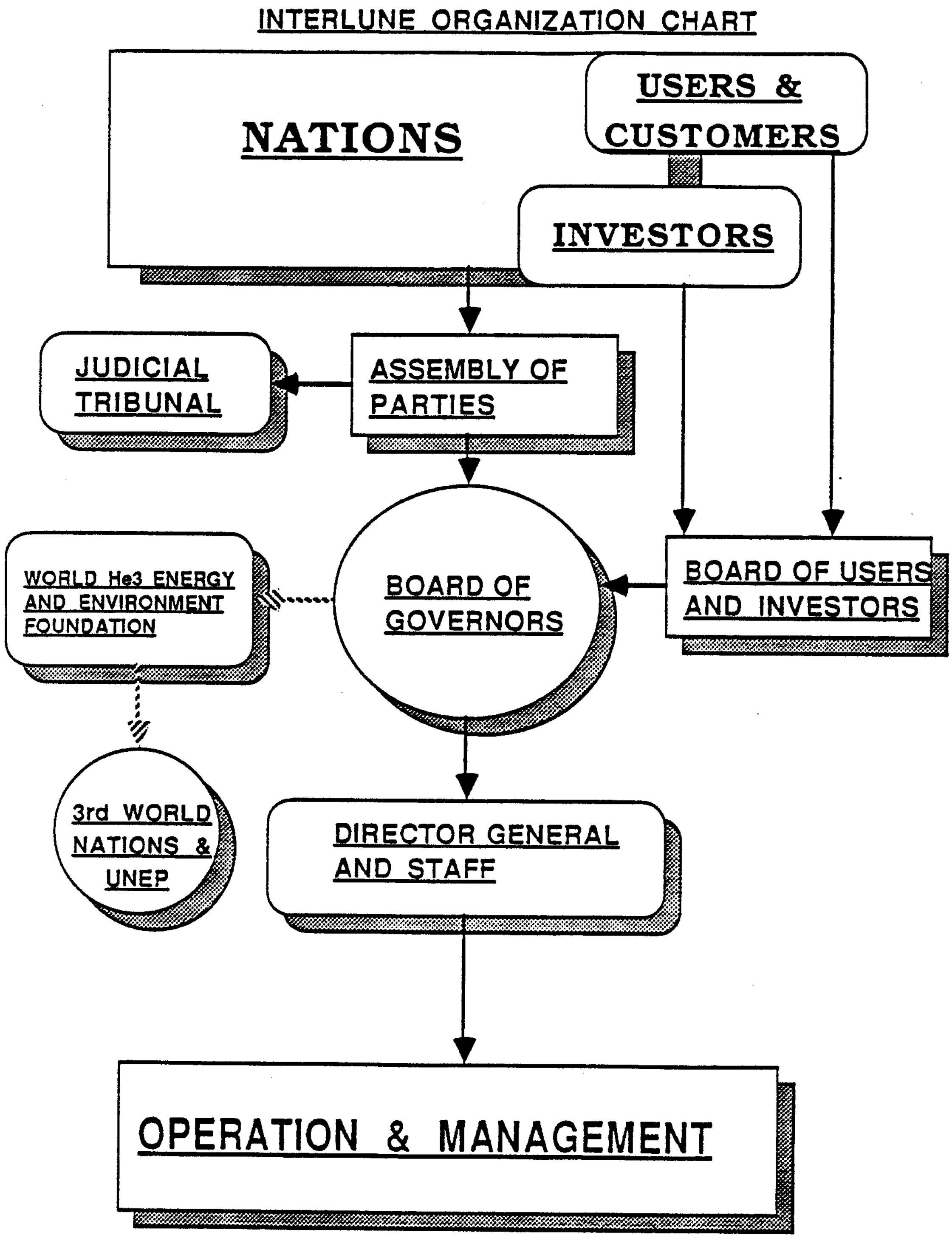

Figure 11. Schematic representation of the management structure and relationship of the INTERLUNE project to private citizens and sovereign governments of the Earth.

The national membership of INTERLUNE would be constituted in the Assembly of Parties. Each Assembly member's interest in INTERLUNE would be proportional to a fair valuation of its aggregate contribution to approved goals and objectives. A member's proportional interest at the beginning of any operating year would set the voting share to which that member would be entitled during deliberations of the Assembly of Parties.

The principal function of the Assembly of Parties would be to establish policy within the legal parameters of an INTERLUNE charter previously negotiated and agreed to by its member states. Under its charter, INTERLUNE might express as its prime goal "the provision of commercial He3 fusion power systems and of lunar resources, facilities, services, and access of high functional potential, safety, and reliability, and of appropriate environmental quality, to be available on an open and nondiscriminatory basis to all peaceful customers, users, and investors."

As ancillary goals, INTERLUNE would be expected (1) to develop a customer base for its products and services, (2) to seek a competitive return on investment in its assets and operations while remaining consistent with meeting its primary goal, and (3) to ensure the neutrality and security of activities under its jurisdiction. In addition, the Assembly of Parties would establish through a Judicial Tribunal the mechanism and forums for the peaceful settlement of disputes relating to provisions in the INTERLUNE Charter or any resultant policy derived therefrom.

Several specific mandates for the Assembly of Parties would be incorporated in the INTERLUNE charter, including the following: (1) to provide general policy guidelines and specified long-term objectives to meet the primary goal of INTERLUNE, (2) to establish general rules concerning nondiscriminatory rates of charge for INTERLUNE's commodities and for the use of INTERLUNE's facilities and services, (3) to consider and adjudicate complaints submitted to it by states, recognized international organizations, users, or investors, (4) to maintain a body of laws, rules, procedures, and instructions for dealing with normal operations and dispute settlement, and (5) to establish general guidelines for the financial participation of potential investors in INTERLUNE. Decisions on all matters for which consensus was not achieved would be taken by three-quarters majority vote.

The Assembly of Parties would be comprised of one representative from each member state. The administrative staff of the Assembly of Parties should be limited specifically to staff functions and proscribed from any interference in the activities of other management entities of INTERLUNE.

The Board of Governors would have the responsibility for the design, development, construction, operation, maintenance, and improvement of INTERLUNE's facilities, services, and resource production and distribution system. Specific duties of the Board of Governors would include: (1) adoption of policies, plans, and programs aimed at enhancing and sustaining the environmentally balanced operation of INTERLUNE, (2) creation and implementation of annual budgets; (3) periodic establishment of rates of charge for commodities produced by INTERLUNE and for the utilization of INTERLUNE's facilities and services in accordance with the general rules set by the Assembly of Parties, (4) solicitation of capital or in-kind participations,

(5) appointment of the Director General and approval of senior staff appointments, and (6) arrangement of contracts with a state, organization, or institution relating to the performance, functioning, and operation of INTERLUNE's facilities and services and resource production and distribution system.

The Board of Governors would be comprised of up to 15 members. One governor each would be drawn from those states, or groups of states, who have made major space investments in support of INTERLUNE (e.g., the United States, the Soviet Union, Japan, China, and the European Space Agency). Two governors would be selected to represent the Board of Users and Investors. The remainder would represent those states, or voluntary groupings of participating states, that would qualify according to a formula based on a fair valuation of actual commitments in INTERLUNE's behalf.

The Board of Governors would endeavor to make all decisions by consensus. However, if consensus is not possible, governors would each participate in the decision process commensurate with the voting proportion of their respective states or groups of states. A three-quarters majority of the total voting participation would be necessary for substantive decisions. The governors representing the Board of Users and Investors would have voting participation proportional to the aggregate fees paid to or capital invested in INTERLUNE. Substantive decisions left unresolved by a three-quarters majority vote could be referred for resolution by the Assembly of Parties by the Director General unless prohibited by a three-quarters majority vote by the Board.

INTERLUNE's Board of Users and Investors would have the responsibility to advise INTERLUNE on all matters of policy and operations that affect the use and financial viability of INTERLUNE's facilities, services, management efficiency, and future expansion. Initially, all committed customers, users, and investors would be invited by the Assembly of Parties to a Charter Conference to establish the organizational structure of the Board of Users and Investors. Upon the Charter's acceptance by three-quarters majority of the initially committed customers, users, and investors, and ratification by the total voting participation of the Assembly of Parties, the Board of Users and Investors would receive staff and financial support from INTERLUNE, and, as aforementioned, would be granted two voting representatives on the Board of Governors.

The executive body, or staff component, of INTERLUNE would be headed by the Director General. Among the Director General's specific duties would be (1) to serve as the legal representative of INTERLUNE and be responsible for all administrative and personnel functions, (2) to contract out to various competent entities technical and maintenance functions associated with INTERLUNE's operations, with due regard to cost and consistency vis-a-vis competence, effectiveness, and efficiency (as probably provided for in the INTERLUNE Charter, private or national entities, consortia of private or national entities, could be utilized), and (3) to serve as the principal negotiator on behalf of INTERLUNE.

Ultimately, INTERLUNE would require the establishment of a dispute settlement system. A first level of this system might be arbitration under the auspices of the Assembly of Parties. A second level could be a Judicial Tribunal, created by the Assembly of Parties, which would serve as a final court of appeals for unresolved disputes, as well as for criminal or civil violations under INTERLUNE's jurisdiction. Importantly in this regard, adoption of a code of criminal and civil law for INTERLUNE would of necessity be agreed to in an addendum to its basic charter, being subject to modification or amendment only by the Assembly of Parties voting through their three-quarters majority vote procedure.

INTERLUNE would be morally if not legally bound to equitably share the benefits of its activities with all peoples. Its basic structure provides for such sharing among nations that participate as investors, users, or customers. An additional financial mechanism is envisioned by which a portion of the eventual profits of the venture would be transferred to a semi-autonomous He3 Energy and Environmental Foundation. The Foundation would be obligated to use INTERLUNE contributions in support of He3 energy development in Third World countries and global environmental enhancement through the United Nations Environmental Program (UNEP).

INTERLUNE is a model organizational concept tailored to provide cooperative international management of commercial He3 fusion power development, lunar resource production and utilization, and lunar base facilities and services for the benefit of its members, customers, users, and investors. Most importantly, INTERLUNE would provide such management through a sharing of both sovereignty and opportunity rather than through unilateral control by any one nation or set of competing nations.

VII.D.4 Rights and Obligations of Members

The INTERLUNE Charter must spell out the rights and obligations of its member nations, users, and investors. Although this would be the subject of much negotiation, a few points appear to be critical to the success of the enterprise.

First, the member nations must agree to refrain from the establishment, or cooperation in the establishment, of any other facilities and services competitive with those of INTERLUNE, unless it is done jointly with INTERLUNE.

Second, the member nations must agree that INTERLUNE facilities and services, including those national facilities and services committed to INTERLUNE by contract, shall be neutral in time of hostilities or threatened hostilities so that INTERLUNE facilities, services, and personnel would remain secure to peaceful use by all nations without discrimination. Thus, INTERLUNE should not be a target of hostile forces in any armed conflict.

VII.D.5 Provision for Self Determination

Inherent in both the concept and the economic potential of establishing a permanent and self-sustaining lunar base producing helium-3 for Earth and resources for other space activities is the high probability that such a base would ultimately become a settlement of permanent residents. If our history on Earth is any indication, such permanent residents will eventually desire a controlling voice in the governance of their activities. We should take this possibility into account in the initial structure of INTERLUNE so as to avoid the conflicts that have plagued colonial establishments in the past.

The best way to provide for self-determination is to create at the beginning of INTERLUNE a clear mechanism by which the settlers can be represented in its organizational entities and by which the settlers can have majority control of INTERLUNE at an appropriate level of population. Thus, the INTERLUNE charter should contain concepts such as the following:

1. The provision for a seat for INTERLUNE settlers on the Assembly of Parties, the Board of Governors and the Judicial Tribunal;
2. The provision for INTERLUNE settlers to receive significant incentive compensation from successful ongoing activities of INTERLUNE.
3. The provision for the systematic accumulation of voting shares for INTERLUNE settlers based on the number of settlers who qualify as permanent residents; and
4. Clear recognition that the success of INTERLUNE will guarantee that its settlers will ultimately gain voting and financial control of the organization if they then desire such control.

The net result of these concepts would be the transition of INTERLUNE from an international development, exploration, management, and investment organization to a true lunar government.

VII.D.6 <u>Implementation</u>

It is never simple to initiate and then implement a new international concept or organization even in the face of as great economic and environmental incentives as may be presented by lunar-supported helium-3 fusion. INTERLUNE would be no exception. However, the establishment of INTERLUNE is clearly possible so long as there is an unequivocal commitment by the United States to the development of helium-3 fusion power and to the establishment of lunar helium-3 production and distribution, and there is a sincere willingness to search for a fair means of international participation in and benefit from such an endeavor.

On the other hand, if the United States appears to be hesitant and uncommitted either to the helium-3 fusion concept, to the establishment of a lunar base, or to international participation in their management, then it is highly probable that the Soviet Union and possibly other nations or groups of nations will "go it alone". If this should happen, a great opportunity will be lost for enhancing the future quality of life on Earth and for increased cooperation and trust among otherwise competing nations. The opportunity for a dominant role for free peoples in space may be lost as well.

Historically, the most logical first step by the United States toward either its own "go it alone" policy or an INTERLUNE approach is to form a for profit, quasi-public corporation such as that created prior to the formation of INTELSAT. The enabling legislation required for the success of this corporation would track that for COMSAT in 1962 but also would address the following points:

- the need for a competitive return on investment for each of the several stages of development of commercial He3 mining and/or He3 fusion,
- successful parallel development of power generation, power distribution, and space resources,

- the need for an irrevocable national commitment, and
- the acceptable framework for international cooperation.

Figure 12 shows one scheme by which the major milestones for helium-3 fusion, lunar helium-3 production, and INTERLUNE might be tied together in time. This scheme is anchored in time by the assumption that it would be technically and economically feasible to activate the first commercial helium-3 fusion power plant in 2015.

With commitment by the United States to helium-3 fusion and a lunar base to support it, the next logical step would be the convening of an international conference to consider a draft of an INTERLUNE charter. This draft charter should be the product of extensive bilateral and multilateral discussion between nations essential to the ultimate political, technical, and financial viability of the organization.

Although not ratified by major space nations, the existence of the Moon Treaty as a negotiated addition to the space law environment nevertheless will be viewed by most nations as the starting point for initiating new international agreements such as INTERLUNE. The development of an INTERLUNE charter along the lines discussed here, and its ratification in the context of ratification of the Moon Treaty, would satisfy most or all of the objections raised against that treaty in the U.S.

The United States clearly should take the lead in this early drafting period, but there is no reason why the final drafting conference should not be by joint invitation of all interested parties. All nations should be invited to send official delegates or observers as they are so inclined. Potential customer, user, or investor entities should be invited as observers or allowed to participate as members of official delegations.

The economic, environmental, and social promise of helium-3 fusion on Earth is great enough that the early activities of INTERLUNE might focus on the research and development necessary to demonstrate its commercial potential. This research and development effort might be the catalyst for the initial organization and financing of INTERLUNE. Indeed, as shown in Figure 12, this approach to INTERLUNE represents an international legal evolution towards the integration of terrestrial and space activities.

The initial forum for discussions of an INTERLUNE Charter might be through the International Thermonuclear Experimental Reactor (ITER) group of nations [5]. These nations are committed to the conceptual design of a large scientific and engineering facility and related research and development activities that will demonstrate the scientific and technological feasibility of fusion power. The participants include the United States, the Soviet Union, the European Community, and Japan with associated participation by Canada and the Peoples Republic of China. The present financial commitment by the participants, totaling $64 million per year for 3 years, provides more than the normal incentive to pursue related cooperative efforts. Thus, the basic principle of a participant-based international organization under U.N. auspices is already in place.

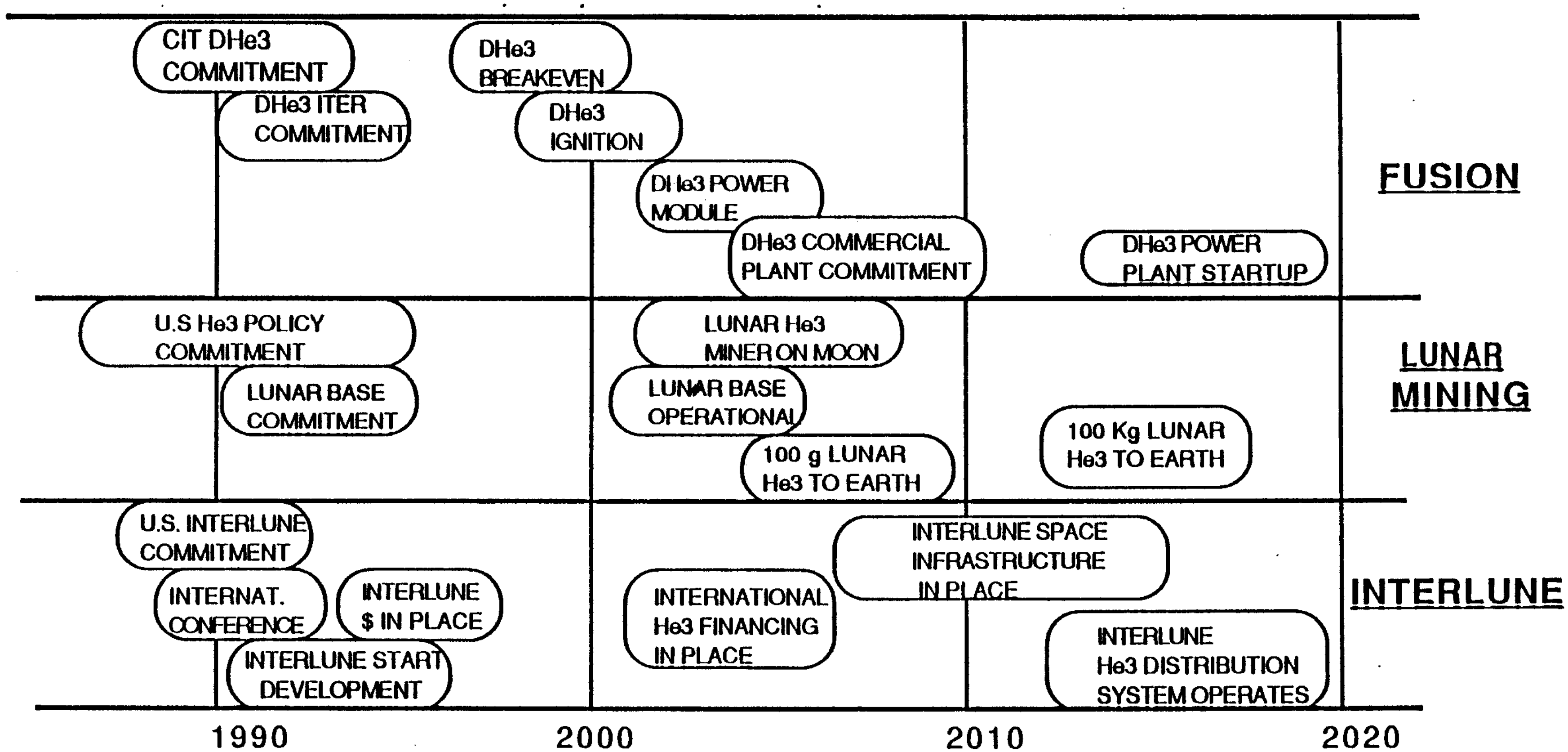

Figure 12. Approximate schedule of major events required to meet a D-He3 power plant start-up in 2015.

An obvious question is, "How can the Soviet Union, the Soviet Block/ nations and the Developing Nations be brought into the development and implementation of INTERLUNE?" The answer lies in helium-3 fusion being "an offer they cannot refuse." Such an offer clearly was made in the case of international management of worldwide telecommunications (INTELSAT) and maritime telecommunications (INMARSAT). The established participation of the Soviet Union in ITER may smooth the way for its participation in INTERLUNE. A commitment by INTERLUNE to divert a significant proportion of its profits to assisting in energy and environmental development can be the basis for equitable sharing of the benefits of lunar resources with the Third World.

An offer most other nations can't refuse also is inherent in the following necessary preconditions to the successful negotiation of an INTERLUNE Treaty: first, an unequivocal commitment by the United States; second, a clear willingness on the part of all nations to share sovereignty, opportunity, and technology; and third, a clear articulation of the direct human, scientific, environmental, and economic benefits to all participating nations.

Once a reality, and once it is clear it will be successful, INTERLUNE will attract many of those nations that may at first be reluctant to participate, as proved to be the case for INTELSAT. Although conceived as an international self-regulating monopoly, INTERLUNE should always be open to new members and investors. Thus, it will achieve its broad humanistic goals as well as its technical, environmental, and economic benefits.

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VIII. DEVELOPMENT OF AN APPROPRIATE LUNAR MINING REGIME

We have argued that U.S. national interest will ultimately require its participation in the development of some kind of multilateral international regime to regulate the exploitation of lunar mineral resources; that is, it appears impractical for the U.S. to try to "go it alone" indefinitely. We have also suggested the general characteristics of a regime likely to be acceptable to the U.S. and some of the forms such a regime could take.

The final question is, assuming that the establishment of such a regime is in fact desirable, how can the U.S. best achieve this goal? Should it seek to negotiate this type of regime now, or should it wait until some future time? If it does decide to wait, what should it do in the meantime to make it more likely to achieve the kind of regime most acceptable?

VIII.A Should the U.S. Try to Establish an Acceptable International Regime Now?

There are a number of reasons suggesting that the U.S. should proceed in the near future to negotiate an acceptable lunar resources regime. First, the substantial investment and complex planning and development process required for lunar resource development--particularly He3 mining--is unlikely to occur without strong assurance that the exploitation of He3 and other lunar resources can occur in a stable legal and political environment. Given the very long lead time required if the U.S. wishes to achieve a technically and economically viable mining operation by early in the next century, we must try to establish an acceptable and secure legal regime as soon as possible. Indeed, even if the U.S. began to negotiate immediately, it might be years before agreement could be achieved. For example, negotiations of the LOS Treaty, the Moon Agreement, and the Antarctic Minerals Convention each took over seven years--in the case of the LOS Treaty almost 12 years!

Second, the strength of the U.S. negotiating position, and its chances of attaining an acceptable regime, may well be greater now than later. The relative power and influence of the U.S., including both its general posture vis-a-vis the developing nations and its position as a space and fusion power, vis-a-vis others such as the Soviet Union, Europe post 1992, and Japan, could conceivably decline in the future.

Third, the general international climate is currently relatively favorable to the establishment of the type of international regime the U.S. is seeking. For example, there is now some measure of U.S.-Soviet detente; the INTELSAT agreement is a currently useful precedent for a sensible type of resource regime; and developing nations, aware of the problems of achieving wide acceptance and effectiveness for the LOS Treaty and Moon Agreement, might prove accommodating. Indeed, if we wait until a possible future time at which the LOS Treaty seabed regime might become firmly established, it could then be impossible to win developing nation acceptance for any other type of international regime more consistent with our ideas, interests, and philosophy.

Finally, it may be easier to establish the relatively open and liberal type of regime we prefer before the feasibility and economic value of He3 exploitation becomes more clearly established and widely known. The philosophy of the Antarctic treaty parties, for example, was that they would have less trouble negotiating and agreeing on a living resource and a mineral resource regime while prospects were still uncertain and exploitation had not yet occurred, than if they waited until a future time when states had developed stronger opposing vested interests or stakes in the outcomes. If developing and other nations come to believe that lunar resources can in fact be economically exploited and great potential benefits are involved, they may be more insistent on a regime which will ensure them much greater control of such activities and a much greater share in such benefits. Thus, it was the highly unrealistic and exaggerated vision of easy wealth from the seabeds spurring the UNCLOS III negotiations that led developing nations to insist on features of the LOS seabed regime that were most objectionable to the U.S. Consequently, there is much to be said for getting at least a framework agreement and rudimentary institutions or arrangements in place at a very early stage and before problems have clearly developed.

But there are also cogent arguments the other way. A first argument is that in view of the recent conclusion of the LOS Treaty and the existence of the Moon Agreement, there is almost no chance that the U.S. can hope in the near future to negotiate--or renegotiate--a more favorable type of umbrella agreement which could conceivably meet its needs; only with the passage of time may such a renewed opportunity open up. Second, the U.S. might be in a stronger negotiating position later than now; for example, it might eventually become apparent that only the U.S., and perhaps one or a few other like-minded "space-powers", will in the foreseeable future have the technology and financial resources to engage in mineral exploitation on the Moon. In that case other nations, if they wanted lunar development to proceed at all, might in effect have no choice but to go along with whatever type of system the U.S. wanted. Or it might be that the LOS seabed regime will be stillborn or collapse, leaving developing and other nations more agreeable to accepting a moon regime more to our liking. In the meantime, we could pursue activities on the Moon and elsewhere expressly designed to strengthen our hand in any eventual negotiations.

Third, given current uncertainty as to feasibility, timing, character, relevant technology or consequences of lunar resource exploitation, it is premature to attempt to develop any detailed international regime at this time; we simply don't now know enough to do a sensible job in this respect. Indeed it was for this reason that COPUOS, in drafting Article 11 of the Moon Agreement, expressly deferred the negotiation of any international regime to such time "as such exploitation is about to become feasible."

We believe that, on balance, the arguments for doing something now outweigh those for waiting or doing nothing. Most compelling, in our view, is the urgent need to provide some assurance of a relatively stable and secure legal and political environment if the necessary long-term investment and planning decisions are soon to be made, and the lengthy and complex development process, with its very long lead-time, is to commence. While we recognize the strength of some of the various arguments the other way, there seems little choice but to at least begin trying to achieve an acceptable and viable international regime now if the prospective timetable for commercial mining of He3 by 2015 is to be met. At the same time, a clear commitment by the U.S. to proceed under any circumstances will improve the climate for negotiations.

VIII.B How Should the U.S. Go About Attempting to Establish an Acceptable International Regime?

Assuming that the U.S. should take steps now towards achieving an acceptable lunar mineral resource regime, what exactly should it do? Should the U.S. reconsider ratifying the Moon Agreement, possibly with reservations? And, if it does ratify, should it then move immediately, within the framework of the Moon Agreement, to negotiate an acceptable regime? Or should it, in effect, negotiate such an acceptable regime beforehand, only then joining the Moon Agreement and incorporating that regime within the Moon Agreement framework? Should it instead, before joining the Agreement, seek a new amendment or protocol to the Moon Agreement or Outer Space Treaty which better protects the U.S. position? Or should it seek to negotiate, either on a broad or a narrow multilateral basis, an entirely new Agreement embodying the type of regime it considers acceptable?

VIII.B.1 Should the U.S. Ratify the Moon Agreement?

If the U.S. wishes to ensure some kind of stable legal regime before it or its commercial enterprises assume a long-term commitment to lunar resource exploitation, then it should consider ratification of the Moon Agreement, simultaneously with clarification of the Agreement and agreement to a satisfactory arrangement for an international lunar resource regime. In this context, we believe that there are interesting arguments in favor of reconsidering the U.S. past refusal to ratify the Agreement, which deserve careful attention.

First, the Moon Agreement is the principal--and may be the only--game in town. Whatever its defects, it represents the best efforts and embodies the carefully considered compromises and accommodations of some seven years of negotiation by the U.S. and the other states most concerned. Moreover, this negotiation occurred in a specialized forum composed of national representatives most expert and pragmatic in this area, and who were relatively congenial to U.S. interests. The U.S. participated fully in this negotiation and achieved most of its negotiating objectives; in fact, the failure of the U.S. to ratify the Agreement, following many concessions made to it, was reportedly viewed by other states in COPUOS as less than good faith. In this context, it seems unlikely that the U.S. could persuade the other states principally concerned to embark on a completely new negotiation, or could hope to achieve anything more in any such separate negotiations than it had already achieved in the Moon Agreement.

Second, the arguments presented in opposition to U.S. ratification in 1980 may no longer be relevant. As indicated in Part V above, suggestions by opponents of the Agreement that the Moon Agreement provides a moratorium, precludes a role for private enterprise, or prescribes any particular type of international regime applicable to lunar resource exploitation--particularly some kind of "socialist" regime dominated by developing nations--do not appear to be supported by either the language of the Agreement or its negotiating history. While Article 11 appears to require good faith efforts to negotiate an international regime at such time as resource exploitation becomes likely, it does not either mandate that the regime take any particular form (particularly not one mirroring the LOS seabed regime) or require states parties not satisfied with any regime which is negotiated to accept it. The criteria set out in Article 11(7) seem consistent with U.S. purposes and objectives.

The negotiation and completion of the Moon Agreement, and its subsequent discussion in the U.S., were contemporaneous with the negotiation of the Seabed Regime in UNCLOS III. As previously noted, the developing nations pressed hard in that LOS negotiation for recognition of certain principles of political-economic ideology (reflected in the developing nations' demand for a New International Economic Order) with which the U.S. did not agree and which it considered incompatible both with the effective development of such resources and our free enterprise philosophy. The sharp controversy that resulted over the seabed regime led ultimately to refusal by the U.S. and certain other major powers to sign or ratify the new LOS treaty. Not surprisingly, opponents of the international seabed regime in the LOS Treaty carried their opposition over to what they saw as ostensibly similar provisions, raising similar ideological issues, in the Moon Agreement. They saw any yielding or concession by the U.S. on the Moon Agreement as threatening a similar failure of will in opposition to the then much more significant LOS Treaty. Given the particularly strong ideological commitment of the U.S. administration at that time, this argument effectively stopped further U.S. consideration of the Moon Agreement. However, some time has passed, this debate is now less intense and active, and a new administration, which may have a somewhat different perspective, is now in office. Consequently, it may be appropriate to at least reassess the pros and cons of the Agreement to see if the reasons advanced in 1980 and 1981 for U.S. refusal to ratify--or even seriously to consider it--should still prevail.

Third, ratification of the Moon Agreement, with conditions which assured protection of U.S. concerns and interests, may be the quickest, as well as the cleanest, way of achieving the U.S. objective of providing some type of stable legal environment in support of a massive and long-term He3 development commitment. The Convention provides a broadly acceptable set of rules--certainly, at least all but those reflected in Article 11--already in place. As indicated in the analysis in Chapter V, these rules seem to meet current U.S. interests in that they do not presently preclude mineral resource exploitation by the U.S. or commercial entities under its sponsorship. It is true, of course, that the Agreement presently has few parties. It may be, however, that this has been primarily because of U.S. failure to ratify; in this case, U.S. ratification might break the dam and be followed by broad accession by many other states, as has been the case with other "space law" treaties. Indeed, the U.S. could informally negotiate or condition its acceptance on similar acceptance by other leading space powers, such as the Soviet Union, the European states, and Japan.

Fourth, while U.S. ratification of the Moon Agreement would not, of course, directly provide a detailed international regime regarding the exploitation of lunar mineral resources, it would put the U.S. in a position to call for and influence the character and structure of such a regime at such time as it wished. Under Articles 11 and 18, only states parties can participate in shaping such a regime; consequently, if the U.S. and like-minded states ratified, they could play a significant and perhaps dominant role in this respect. Indeed, as a party, the U.S. could move immediately to initiate a gradual process directed at developing elements of a regime as needed at various stages of progress in the mineral exploitation program. (Article 18 permits a majority of the parties to call for a review conference, which could consider the establishment of a new international regime, five years after the agreements entry into force, or as early as 1989.) Conversely, if the U.S.

continues not to ratify the Agreement and is not a party, it abdicates any role in the shaping of any such potential regime to those states which are parties.

Fifth, to the extent that concern as to the meaning or ideological implications of the Agreement continued to pose a political obstacle to U.S. ratification, such concerns could conceivably be met through appropriate U.S. reservations, declarations or understandings to its ratification of the Agreement. For example, the American Bar Association's International Law Section, in a 1980 Report recommending U.S. ratification of the Moon Agreement, suggested that any such ratification be accompanied by the following understandings and declarations:

(a) It is the understanding of the United States that no provision in this Agreement constrains the existing right of governmental or authorized nongovernmental entities to explore and use the resources of the Moon or other celestial body, including the right to develop and exploit these resources for commercial or other purposes. In addition, it is the understanding of the United States that nothing in this Agreement in any way diminishes or alters the right of the United States to determine how it shares the benefits derived from exploitation by or under the authority of the United States of natural resources of the Moon or other celestial bodies;

(b) Natural resources extracted, removed or actually utilized by or under the authority of a State Party to this Agreement are subject to the exclusive control of, and may be considered as the property of, the State Party or other entity responsible for their extraction, removal or utilization;

(c) Recognition by the United States that the Moon and its natural resources are the common heritage of all mankind constitutes recognition (i) that all States have equal rights to explore and use the Moon and its natural resources, and (ii) that no State or other entity has an exclusive right of ownership, property or appropriation over the Moon, over any area of the surface or subsurface of the Moon, or over its natural resources in place. In this context, the United States notes that, in accordance with Articles XII and XV of this Agreement, States Parties retain exclusive jurisdiction and control over their facilities, stations and installations on the Moon, and that other States Parties are obligated to avoid interference with normal operations of such facilities.

(d) Acceptance by the United States of an obligation to undertake in the future good faith negotiation with other States Parties of an international regime to govern exploitation of the natural resources of the Moon in no way prejudices the existing right of the United States to exploit or authorize the exploitation of those natural resources. No moratorium on such exploitation is intended or required by this Agreement. The United States recognizes that States Parties to this Agreement are obligated to act in a manner compatible with the provisions of Article VI(2) and the purposes specified in Article XI(7); however, the United States reserves to itself the right and authority to determine the standards for such

> compatibility unless and until the United States becomes a party to a future resources exploitation regime. In addition, acceptance of the obligation to join in good faith negotiation of such a regime in no way constitutes acceptance of any particular provisions which may be included in such regime; nor does it constitute an obligation to become a Party to such a regime regardless of its contents.

Whatever the merits of these particular proposals, some kind of reservations meeting our legitimate concerns could be devised.

As against this approach, the U.S. would have to consider several important arguments against U.S. ratification of the Moon Agreement, raised in the 1980 Hearings and deserving serious attention. The argument is based essentially on a pessimistic prediction of the likely outcome of any eventual Article 11 and 18 negotiation to develop an international regime for lunar mineral resource exploitation. In this view, most of the states which eventually become parties to the Moon Agreement are likely to be developing or "Third World" nations (which of course constitute a clear majority of the nations of the world). These nations will most likely seek to advance their own interests and their "New International Economic Order" ideology and approach in the operation and development of the Agreement and in any future Article 11 and 18 negotiations of a new regime. And, because of their numbers, they might well prevail! Thus, the net effect of U.S. ratification of the Moon Agreement may be simply to make viable, strengthen and add to the prestige and importance of an Agreement and eventual resource regime which is likely ultimately to embody principles and work in ways opposed to the interests of the U.S. and its commercial enterprises. Thus, our ratification will, in effect, lock the U.S. into a clearly losing game.

Moreover, U.S. ratification may effectively preclude our pursuit of any alternative, more hopeful strategies. While it is true that the U.S. is not legally obliged under the Agreement to agree to an eventual international regime it doesn't like, it may by that time be too late for the U.S. to either "go it alone" or to seek some other agreement. That is, by participating in the negotiation of a regime under the Moon Agreement and in that forum, the U.S. may make it much more awkward and difficult for it to subsequently reject the result. This, for example, was U.S. experience in the recent negotiation of the Law of the Sea Treaty.

To meet these concerns, the U.S. could conceivably negotiate with like-minded nations having a present or potential capability in space and concern with the eventual effective development of lunar resources--e.g. the Soviet Union, Canada, European countries, Japan, perhaps China--for a simultaneous ratification of the Moon Agreement, coupled into a joint declaration indicating the kind of resource regime they intended to seek to establish under Article 11 (5). The U.S. could even issue an immediate call for a conference to establish such an agreed regime. Given the present limited number of parties to the Agreement, these "new" parties would constitute a majority and presumably be in a position to both call such a conference and adopt a regime of their choice. Indeed, these countries might "negotiate" a regime which they considered acceptable before such simultaneous ratification, and have a conference immediately after becoming parties simply to ratify their prior understanding.

VIII.B.2 Should the U.S. Attempt to Establish Some Kind of Lunar International Regime Different From or Outside of the Framework of the Present Moon Agreement?

As indicated, any attempt by the U.S. to establish a lunar regime apart from and potentially in opposition to the Moon Agreement would almost certainly encounter criticism, opposition and difficulty. However, some precedent for this approach exists in U.S. rejection of the 1982 Law of the Sea Treaty (in particular, the Seabed Mining provisions and regime of that treaty), in the U.S. continued position that in principle deep seabed mining is a high seas freedom, and in the U.S. conclusion in 1982 and 1984 of international agreements with several other states (Belgium, France, the Federal Republic of Germany, Italy, Japan, the Netherlands and the U.K.) to resolve overlapping claims with respect to mining areas for polymetallic nodules of the deep seabed. (Indeed, in 1984, pursuant to the U.S. Deep Seabed Hard Mineral Resources Act of 1980, four licenses for seabed exploration were granted by the U.S.) The possibilities open to the U.S. in this respect include the following:

First, the U.S. could propose some kind of change in or addition to the present Moon Agreement--or conceivably the Outer Space Treaty itself--that would clearly protect and provide for the right of any state or private enterprise to mine, acquire property rights in, and exploit lunar mineral resources and to retain all or most of the profits. These changes or additions could spell out, in whatever detail desired, the precise kind of mineral resource regime, rules or institutions that the U.S. would most prefer. Since the U.S. is not a party to the Moon Agreement, it could not itself propose amendments to that effect in the Agreement, although another state which was a party and in sympathy with U.S. objectives could do so. However, the U.S. could propose the negotiation of a Protocol (or additional instrument) to the Agreement, which presumably could be negotiated within COPUOS with U.S. participation, or it could conceivably, as a Party to the Outer Space Treaty, propose an amendment to that instrument. As stated, such a U.S. initiative would most likely meet a cool reception.

Second, the U.S. could propose the negotiation, on a global basis, of a broad and entirely new Moon Agreement intended to replace the present agreement, and containing different and possibly more detailed provisions reflecting U.S. preferences. Such a negotiation could conceivably occur either within COPUOS or outside the UN framework. Again, it seems unlikely that such a proposal would engender much enthusiasm.

Third, the U.S. could propose to take the initiative to set up an organization similar to the INTERLUNE concept which was explained in Chapter VII. Such a proposal could use the INTELSAT model or one more specific to INTERLUNE itself. The probability of success for this approach strongly rests on the perception of a profitable commodity such as He3. At this stage of fusion research, only the most technologically advanced nations would be in a position to access the eventually financial and environmental impact of this fuel, but those are also likely to be the same nations with the capability to establish a lunar settlement in the early 21st century. There is a better match between interest and capability in this approach compared to the first two suggestions.

Finally, the U.S. could--taking the same approach it adopted with respect to the issue of deep seabed mining--attempt to negotiate a lunar mineral resources agreement only with those like-minded states actually engaged in space activities and showing interest in and a potential capacity to engage in lunar mining activities. For example, this would include the Soviet Union, the European Community, the Peoples Republic of China, Japan, India and a few others. Preferably, such an agreement would not attempt to deal with lunar activities as a whole--which are already broadly covered in the Outer Space Treaty and in provisions of the Moon Agreement that may be binding as customary law--but would deal only with the provision of rules, relating more directly to the exploitation of lunar mineral resources. For example, an agreement of this type could draw on the precedent of the INTELSAT Agreement or even the INTERLUNE concept discussed in Chapter VII.

If objections are raised that it is premature to try to agree now on a detailed legal regime, since exploitation is unlikely for at least 25 to 30 years, the U.S. might propose present agreement on at least a broad "lunar resource principles" agreement, expressing a firm commitment to the basic framework and character of such a regime. If the U.S. is now able to obtain firm assurances that the lunar mining regime will ultimately reflect general principles acceptable to the U.S. government and private enterprises, the U.S. may be willing to agree to defer negotiation of the precise details of such a regime until mining activities are more imminent.

VIII.C <u>What Else Should the U.S. Be Doing? Other Factors Affecting the Achievement of an Acceptable International Regime</u>

Apart from U.S. policies and efforts expressly directed at achieving an acceptable lunar mineral resources regime, there are a number of other things that U.S. policymakers may wish to keep in mind as potentially affecting this goal.

First, the U.S. should seek to strengthen helpful terrestrial precedents and to weaken those which are not helpful. Thus, the Antarctic Mineral Resources Convention and the INTELSAT Agreement appear to be generally helpful precedents for the kind of regime the U.S. favors; we should try to bring that Convention quickly into force and do all we can to make it work. Conversely, it would be useful to minimize the precedential effect of the LOS Treaty's Seabed provisions and regime, perhaps by eventually working out a new compromise between the developed and developing nations which trades developed nation acceptance of the Treaty for removal or change in its most objectionable features. Certainly, the experience over time under both the Antarctic and LOS Seabed regimes will be highly relevant to the shaping of any eventual lunar regime.

Second, U.S. space activities should continue to be carried on in a responsible and internationally cooperative way. To the extent that the U.S. is viewed by other nations as a responsible and trustworthy partner in the exploration and use of outer space and celestial bodies, we will likely find other nations similarly more cooperative. To the extent our attitude and approach is seen as unreliable, unilateral, highly competitive, or exploitative, we may expect less cooperation and more distrust.

Third, the U.S. may wish to exercise some care as to what it says or begins to do about lunar resource exploitation--in particular, about He3. For instance, as an extreme example, any suggestion that the U.S. and its private enterprises were preparing to: (1) appropriate much of the He3 from the Moon, thus taking exclusive control of an extremely valuable source of energy, vital to humanity's future; (2) churn up vast areas of the Moon's surface for this purpose without respect for environmental considerations or the attitude of other states or the public; and (3) accumulate vast profits through its monopoly control of He3, would obviously not be helpful. Indeed, this would meet the Third World's caricature of how the U.S. and the free-enterprise system work. Consequently, considerable care might be called for to avoid such reactions or charges, and to reassure "public opinion" that U.S. mining of He3 represents no threat and is very much in the interest of all countries. It might, perhaps, be desirable that any planning and public statements and proposals clearly manifest a recognition by the U.S. that any lunar activities will have to be conducted with respect for environmental concerns and awareness of other international responsibilities including global environmental protection.

Finally, if, as here suggested, the U.S. decides that it will be desirable in the relatively near future to take some initiative to put an acceptable international lunar regime in place, it should now begin quietly to lay the groundwork essential to gaining international support for such a development. This may involve appropriate low-key consultation with other governments, brief mention of the problem in official speeches and reports, studies, panel discussions at conferences, and so forth. There is a very good case for the establishment of the kind of regime the U.S. wants, but it has to be made clearly and persuasively!

IX. CONCLUSIONS

(1) The deuterium-He3 fuel cycle offers significant safety and environmental benefits as an alternative source of electricity in the 21st Century when compared to the use of coal or uranium.

(2) Given the current rate of research and development in plasma physics and fusion reactor design, it is possible that the first safe and efficient commercial power reactors utilizing He3 could be operated as early as the year 2015.

(3) The D-He3 fuel cycle appears to be economically competitive with other early 21st Century fuel cycles.

(4) It has been scientifically established that vast amounts of He3--sufficient to provide energy for humanity for at least 1000 years--are available on the surface of the Moon and can be extracted and transported to Earth utilizing reasonable extensions of existing technology.

(5) He3 is readily extractable from lunar regoliths by methods analogous to those used in surface mining on earth, using temperatures readily attainable on the Moon and by using known methods of separating He3 from He4 and other gases. Those gases, hydrogen and nitrogen in particular, would be valuable by-products for life support on the Moon and Mars, and for space transportation.

(6) The process of exploitation of lunar He3 is likely to have little detrimental effect on the lunar environment or other uses of the Moon, and will produce by-products (e.g. H_2, H_2O, N_2, CO_2,CO,CH_4, etc.) of great usefulness and importance for the establishment and maintenance of a lunar base or bases on other planets.

(7) An integrated earth-lunar He3 mining and power production system will require a large, complex, and carefully coordinated effort over at least a twenty-five to thirty-year period; private enterprise could play a key role in this development.

(8) Existing space law and other international arrangements suggest that an acceptable basis can be found for cooperative international production of lunar He3. These precedents include various types of national mining laws; the Antarctic system experience; the Moon Agreement; and the INTELSAT, INMARSAT and Space Station Agreements.

(9) Government and, even more so, private investment in the development of a He3 mining and energy system will be difficult in the absence of a stable and predictable legal regime that could provide a reasonable assurance that any such effort and investment will be rewarded. A legal regime must be established which will permit nations or private enterprises to mine and process He3 (and other gaseous by-products) on the Moon, to acquire property rights in the materials and processes, to transport products to earth, to utilize them for the production of energy at a profit, and to retain at least a sufficient share of such profits to warrant the effort, investment, and risk involved.

(10) It is in the U.S. national interest, in the near future, to establish an acceptable lunar resource regime, or at least a commitment to the type of regime acceptable now to the U.S. This needs to be done now instead of waiting for future developments to spur on other nations that may then be in a stronger position than the U.S. vis a vis space capabilities.

(11) A lunar resource development regime acceptable to the U.S. should meet certain criteria, including the following: it must

(a) permit the U.S. and private U.S. enterprises to effectively conduct lunar mining activities, acquiring property rights in the product, transporting it to Earth, and retaining reasonable profits from such activities;
(b) be consistent with international law;
(c) encourage international cooperation; and
(d) recognize and be sensitive to other broader international community and public concerns, particularly with respect to the environmental concerns.

(12) The Law of the Sea Treaty and Antarctic Mineral Resources Convention represent two different approaches to devising an international framework for resource development. The first is an attempt to involve all nations equally in resource development under the guidance of the United Nations. It has been strongly opposed by the U.S. and other western industrial nations. The second calls for control by only those nations actively involved in Antarctic exploration and environmental research. It appears to be on the verge of ratification. Lessons for the development of He3 can be learned from both of these international proposals.

(13) The Outer Space Treaty and the Moon Agreement state general principles that currently guide international thinking on the exploration of space and the Moon, and obligations of participating states. The Moon Agreement calls for establishment of an international regime for the Moon, but does not spell out the structure of such a regime at this time.

(14) The INTERLUNE concept describes an attractive legal structure for the use of resources from the Moon, and it includes policy-making, governing, and executive bodies. Control would be vested in states currently active or soon to be active in lunar exploration, but allowance is made for future participation by other states as they develop the capacity for and commitment to lunar development.

(15) The long economic, practical, and legal experience of the U.S. in encouraging private sector involvement in mineral resource development, along with the potential environmental urgency of developing early 21st Century energy alternatives, suggests that the U.S. could and may have to consider unilateral development of the D-He3 fuel cycle and lunar He3 production if other nations choose not to participate.

(16) While the U.S. could proceed unilaterally, there are a number of arguments in favor of establishment, by the U.S., of an international lunar resource regime on a multilateral basis. In particular, an internationally-supported regime, properly configured, could be more stable and predictable over the long time period involved, reduce the likelihood of disputes, provide the basis for mutually advantageous cooperation, and thus provide a more secure investment climate favorable to long term commitments.

(17) One way the U.S. might proceed toward an international regime is to set up a quasi-public corporation to undertake its development and operational activities, seek agreement on an acceptable lunar resource regime among the "space powers", and then to seek to incorporate this agreement within the framework of the Moon Agreement. This could be done by having the nations agree to such a regime in advance, with an arrangement under which they will then simultaneously ratify the Moon Agreement and call for a conference on Articles 11(5) and 18 to formalize this previously agreed resource regime within the Moon Agreement's own treaty framework. Alternatively, if ratification of the Moon Agreement proved politically unachievable, an independent agreement on an acceptable lunar resource regime might be concluded, outside the framework of the Moon Agreement, perhaps incorporating and consistent with the general tenor and provisions of the Moon Agreement apart from Article 11.

(18) The difficulties experienced by consensus and "one nation-one vote" organizations in the management of international enterprises, and the success of user interest organizations like INTELSAT, strongly suggests that the INTELSAT approach might be preferable in the management of international fusion and lunar resource development.

(19) Of proposals thus far offered for the Moon, the INTERLUNE concept is the most advanced in its development of a legal structure and is consistent with U.S. commitments and policies with regard to space. It would ensure a role for both private and national enterprises, protect the consumer, provide for environmental protection, and provide for eventual participation by all states in proportion to their commitment and contributions to lunar development.

(20) The nation must make an unequivocal commitment, backed by sufficient human and financial resources, to be the dominant player in space and in the development of a lunar helium-3 energy system for the Earth. This commitment is necessary if the U.S. is to have either a national or international option for a future in space and, potentially, for the future of the Earth's environment. With such a commitment, the pressure on the rest of the world to join with us in a workable international management organization will be enormous. Without such a commitment, we may not be invited to play a serious role in a Soviet, European, or Asian-dominated effort which might arise.

X. RECOMMENDATIONS

(1) NASA, along with other federal agencies (Dept. of State, Dept. of Energy, Dept. of Commerce, etc.), industry and universities should integrate the appropriate aspects of existing international arrangements (e.g., the Moon Treaty, INTELSAT, or the Antarctic Treaty) into a policy framework for the successful development and utilization of lunar volatiles.

(2) In parallel to recommendation (1), NASA should also develop and evaluate an alternative United States "go it alone" strategy for the extraction and use of lunar He3 resources.

(3) NASA should undertake a detailed examination of the proposed INTERLUNE organization as a possible approach to the international management of lunar resources.

(4) The United States, through NASA and in consultation with other qualified governmental agencies, professional societies, and commercial entities, should convene a national workshop to undertake an in-depth examination of:

(a) the type of acceptable lunar resource legal regime which would meet the United States needs,
(b) the optimal strategy for the United States to achieve such a legal regime.

(5) The United States, through NASA and the State Department, should consider the feasibility of achieving an early consensus with other "space powers" on an acceptable legal regime by either collective ratification of the Moon Agreement with simultaneous inclusion of the preferred legal regime into Articles 11(5) and 18, or by means completely independent of that Agreement.

(6) NASA should undertake, in cooperation with other federal agencies (DOE, NOAA, EPA, etc.), a net assessment of the total environmental effects associated with the production of electrical energy through the D-He3 fusion fuel cycle. This assessment should include;
(a) terrestrial effects such as reduced thermal, air, and radioactive pollution,
(b) increased safety aspects of terrestrial D-He3 fusion plants,
(c) environmental impacts on the lunar environment such as surface alterations, vacuum degradation, waste products, etc.

It is important that NASA demonstrate, from the very beginning of lunar resource utilization, its openness to the receipt of outside views on environmental matters and a willingness to accommodate valid public concerns.

(7) NASA should encourage the Dept. of Energy to:

(a) Pursue D-He3 research in present fusion facilities such as TFTR at Princeton.
(b) Include D-He3 research capabilities in the proposed Compact Ignition Torus (CIT) and the International Thermonuclear Experimental Reactor (ITER).
(c) Increase emphasis on the conceptual design of D-He3 commercial power plants.

(8) NASA should undertake (along with DOE, Dept. of Interior, Dept. of Commerce, industry and the university community) a detailed assessment of the economic competitiveness associated with the D-He3 fuel cycle. Such a study should establish the allowable variations in key economic parameters, including environmental credits in the 21st century.