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Paper Session I-B - Maximization of Benefits From the Space Exploration Initiative

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by

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Introduction

On the 20th anniversary, in 1989, of our country's triumphant first landing on the surface of our moon, the President of the United States once again challenged the nation to excel in space. Since that time, a series of outreach efforts was initiated by NASA to the aerospace industry, federal agencies, and the public. In addition, the Vice President of the United States chartered an Advisory Committee on the Future of the U.S. Space Program. At this writing, the AIAA has submitted a report on their canvass of the aerospace community, and the Advisory Committee report has been published. The synthesis group is in the conclusion preparation phase and should have the report completed by the time of this conference. Although each of these groups has taken different approaches, a consensus does appear that agrees with the President's objectives. Whether the schedule or architectures agree, they all recommend a ..."balanced Space Program for America. We will, within budgetary limits, reenergize our country's thrust into space through a renewed dedication toward the long-term magnet for the manned space program ... the human exploration of Mars." This, of course, is the long-term goal coupled with the science, mission-to-planet Earth, expanded technology and development of a robust space transportation system that make up the balanced program recommended.

The authors do not disagree with the goals, objectives, or recommendations of the two reports published to date nor will we differ with the synthesis conclusions after they become apparent. We will briefly summarize the results of an analysis conducted by McDonnell Douglas and Eagle Engineering in the second and third quarters of CY90. The results will show the benefits of space programs and suggest an overall approach to space architecture that could help maximize the world benefits of space while still meeting the overall objectives of the three sets of recommendations mentioned above. We acknowledge the work of the contributors to the AIAA report and to numerous NASA studies of specific endeavors such as the Lunar Energy Enterprise study. This paper is a much shortened version of the entire treatment. A more complete presentation will be available from the authors at the conference if desired.

The Premise

Our nation's approach to space to date has been typified by the activities pursued by the industry since the President's challenge 20 July 1989. We have all busily analyzed the how of the future rather than the why. We have generated scenarios based on achieving a perceived goal within cost and schedule guidelines. Previously, our thought process encompassed reaching the goals, then telling the public, the ultimate paymaster, that it was good for them. We list transistor radios and weather satellites and attempt to conduct benefit analysis after the fact, then imply great future benefits of unknown nature from the next program. This approach has failed to capture adequate support from both the public and the Congress. We have a great task before us. How do we change both the public and Congressional opinions and how might the program be structured to aid in the improvement of national support?

As in all problem solutions, the most difficult and sometimes preeminent task is that of properly posing the question. A problem as global as this requires some precise structuring to limit the discussion and direct our thoughts. Table 1 is such a statement. We will utilize this set of questions to structure the remainder of our presentation. We will deal with the general benefits to the United States of Civil Space, then we will propose an approach that might maximize the benefits of the Space Exploration Initiative (SEI) to not only our nation, but the world.

U.S. Economy

For our purposes, we are defining the U.S. economy in terms of the trade balance, export-import data, per-capita income, and the consumer price index.

The U.S. trade deficit has reached its highest figure in recent years. Aerospace and agriculture are the only significant U.S. industries with trade surpluses. Recent

Table 1. First Order Questions

- In many difficult problems the most important task is to properly pose the question . . .
  - How do you evaluate the economic feedback potential of some technology?
  - What makes up the U.S. economy?
  - What have been the major feedbacks (spin-offs) into the economy in the past?
  - How many dollars in the program would really go into technology development?
  - How many dollars are invested annually in the U.S. in R&D?
  - How do you evaluate the scientific feedback potential of a given trade?
  - How does a given program influence the educational system, particularly higher education?
  - What other ways does a NASA program influence the folks back home?
  - Who are the interested parties and what part do they really deserve?

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events such as the sale of advanced fighter technology to Japan and competition in the commercial space launch market will no doubt reduce world dependence on our aerospace technology and further reduce exports.

The U.S. trade imbalance is primarily with Japan; however, we run trade deficits with all the major economic powers. These data are for 1989, a period before the European economic realignment, takes place in 1992. The U.S. has lost the lead in electronics, machinery, manufactured goods, and automobile exports. A concentration in space research at the universities and U.S. industries will maintain our dominance in aerospace and possibly agriculture, create new technologies for manufacturing, promote more competitive products, and help close the electronics gap by recovering our dwindling lead in high technology electronics.

In terms of per capita income, the U.S. is improving when compared to Europe and Japan due to falling unemployment (a trend reversed in the first quarter of FY91) and inflation rates. Japan has highest per capita income with Italy and Great Britain bringing up the rear. As our country's employment level declines, one of the few hopes to reverse the trend is the space program. In terms of consumer price index (a comparison of the average change in prices over time in a fixed market) the U.S. and Europe have been relatively stable at $\approx$ 6% over the last few years, but Japan is gaining from the decreasing levels of 1987. Nevertheless most all countries have similar trends; we are approaching a global economy.

In conclusion, the trends below appear.

- The U.S. has overall trade deficits with every major participant of international trade.

- Exports of aerospace and agricultural commodities account for the only significant accumulations in U.S. trade.

- The U.S. spends approximately \$2 for every \$1 it sells in trade with Japan.

- Per Capita Income in the U.S. is on the rise due to recent declines in inflation and unemployment, but this trend may be short-lived.

- Trends in the Consumer Price Index changes for all economic powers indicate the very global nature of the economy.

We must reverse these trends. One of the few areas that could change the ever decreasing economic trends is the space program because it affects the aerospace industry.

The U.S. Economy and Civil Space

The relationship of Civil Space to the U.S. economy, the R&D planned in FY91, and past spin-offs realized from Space Expenditures will be shown in this section. The general effect of Civil Space on the U.S. economy is summarized below.

- Highlights of FY90 \$12.3 billion procurement expenditures will create, directly and indirectly:
  - 237,000 jobs in private industry
  - \$23.2 billion in total industry sales
  - \$2.4 billion in corporate profits
  - \$7.4 billion in federal, state, and local tax revenues
  - \$500 million in related industry independent research and development

- States benefiting most from U.S. space program are those with large aerospace industries, but other states also benefit significantly.

- Many industries other than aerospace benefit from NASA procurement as indicated by high economic multipliers.

One of the surprising results of this analysis is that over and above the direct benefits received by the states with major aerospace industry there are indirect benefits in all states ranging from 4 to 1 ratios in the major beneficial states to as high as 10 to 1 in states such as Kentucky, Oklahoma, Indiana, and Michigan, not normally considered as players in the aerospace industry. A summary of the pull-through from Civil Space to our national economy is shown below.

- Approximately 17% of jobs created fall within engineering, science, and skilled labor fields.

- Many jobs created are for blue collar and lesser skilled labor not normally linked to the space program.

- Every state in the U.S. receives economic and employment benefits from NASA procurements.

- States directly benefiting have economic ratio as high as 14.0 to 1.

■ Indirect benefits to states also have economic multipliers of significant value.

Spin-Offs From The Past

A summary of spin-offs and feedbacks from past Civil Space programs can be found in Table 2. These data are further augmented by the data shown in Table 3, which contains an estimate of the worth of technological pull-throughs subdivided by end use. The data were generated by the Chapman Research Group for the period from 1978 to 1986. These data are derived from programs that resulted from goals that were not specifically structured to produce benefits.

The above ignores the overall feedback into the aerospace industry competitiveness as a whole. It is important to note that many foreign companies are teaming as are foreign nations in pursuit of Civil Space government and commercial endeavors. The public somehow sees only the money spent. The aerospace community must help publicize spin-offs in the microelectronics, medical, and life science, software, materials research, and other areas that best fed back into the civilian economy.

Table 2. What Were Past Spin-offs and Feedbacks?

- Over 32,000 spin-offs, NASA does not accurately track dollar value:
  - Cannot identify most important
  - Estimated dollar value : $10 billion to $100 billion
- Most important spin-off—U.S. aerospace industry still #1 on Earth:
  - One of few U.S. industries with close government and industry cooperation in R&D
  - DOD is a major part of it all
  - Difficult to point to one factor—perhaps total NASA and DOD R&D budget
- Second most important spin-off—large numbers of technically trained people:
  - Feeds back into all other U.S. technical endeavors
  - Difficult to quantify in terms of patents and products
- Third most important spin-off—technical and practical knowledge of what can and should be done in space—how space and Earth relate.
- Fourth spin-off—specific hardware and software:
  - Almost all small items, individual dollar values are not large.
  - NASA tracks and documents many through Technology Utilization and Patent Office.

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Higher Education

The education problem in the United States has been analyzed many times. The facts of rising illiteracy and the percentage (50%) of foreign doctorates who return to their country of origin is startling. In a recent Chinese space program personnel description, over 95% of those leaders whose biographies were given were U.S. educated. Our science and engineering schools are recognized throughout the world for excellence, but the number or percentage of U.S. students is declining. If the U.S. desires to maintain its leadership role in space and be competitive in industry, it must start by encouraging young students to select engineering and high technology fields to meet demands.

The classic case of Apollo still should be noted. The effects of decreased NASA spending following Apollo was to decrease the number of doctorates received a few years later. This lag can be attributed to the fact that many students were well on their way to achieving high-level degrees when NASA cutbacks began to take place. After it was clear that NASA funding was decreasing along with federal support for students, the number of students pursuing doctorates in these fields plummeted. The Apollo program had two direct effects on the Ph.D population. First, the lag seen between the peaks of degrees conferred and NASA spending caused a surplus of highly trained people causing unemployment. Second, the lag caused many prospective students to seek other careers due to the lack of commitment by the government for space activities leading to the engineering shortfalls seen today.

Table 3. Benefits Realized from NASA-Furnished Technology Case Applications from Spin-off Reports By Categories of End Use Sales or Savings, $K*

End Use Description	Number of Cases	Number of Cases with Sales or Savings	Benefits Sales	Realized Savings	Total
Communication and Data Processing	51	32	171,007	51,964	222,971
Energy	30	13	203,500	15,613	219,113
Industrial (mfg & process)	170	107	5,767,649	67,837	5,835,486
Medical	61	31	2,003,036	30,613	2,033,649
Consumer Products	24	18	1,278,294	524	1,278,818
Public Safety	27	16	347,888	555	348,443
Transportation	40	18	9,887,865	116,623	10,004,488
Environmental	16	111	6,962	21,788	38,750
Other	22	13	1,654,989	10,232	1,665,221
Total	441	259	$21,331,190	$315,749	$21,646,939

*Estimates were obtained from company officials, or derived from company estimates of manpower or other types of savings. The 441 cases were reported in Spinoff magazine, 1978-86; of these 368 had acknowledged sales or savings, but 109 cases could not be estimated as to extent.

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A few conclusions can be reached about the higher education connection. It is essential that a long-term continuous commitment to space exploration be made. These goals will attract young people to make a commitment to their future. We must convince the present elementary school students to commit to science and engineering; they are the key to our future. A companion paper given at this conference discusses one corporation's commitment to intriguing the young. Our conclusions follow:

■ Long-term government commitment to space exploration is the key to attracting young people to endeavor in high technology careers.

■ Students entering engineering fields have dropped in numbers as well as suffering high attrition rates leading to industry wide shortages of engineers of all disciplines.

■ The Apollo program established the relation between space exploration and education as enrollment increased and decreased along with program funding and support.

■ Space exploration must have both near and long term goals to attract young people now and make a commitment to their future.

Civil Space Participants

As has been discussed, NASA contracts are present in all of our states. The SEI program will utilize both DOE and DOD laboratories and many universities for its research and development. Even though Space, Science, Commerce, and Transportation Committees are represented by aerospace-dominant states with more emphasis in the House than the Senate, the Civil Space budget is not widely supported. It is realized that the percentage increase given in GFY91 was more than any other federal area, but the general support for Civil Space is still poor. Too many of the public and too many of our Congress does not perceive the benefits of Civil Space; we must inform them.

World Benefits Through Goal Setting

In the premise we proposed that the Civil Space program can be oriented in a direction that will not only help solve world problems of the present and future, but also help ensure a long-term continuous effort. The basic idea is presented in Table 4. We propose that scenarios be developed for SEI that utilize technologies indigenous to future problems of the world. One of the authors has the good fortune of having twin sons in college who associate with a group of students from other nations, all of whom are studying in the U.S.A. preparatory to returning to their home countries after graduation. Upon query, these young people agreed on a list of problems they feel the world will be concerned with in the next 50 years. This is not to say that there was total agreement as to sequence, but, rather, in overall content. The list follows.

Table 4. The Basic Idea

- Previous scenarios have generally minimized cost within the scope of certain ground rules such as:
  - Return to lunar surface first to stay.
  - Mars mission follows.
  - Advance space technology.
- Development dollars and technology push tends to focus on minimizing mass in low Earth orbit and following previously charted paths beyond current boundaries
- New scenario ground rules, in order of priority:
  - Development dollars focused first on agreed upon technologies most likely to feedback into civilian economy
  - Development dollars focused second on agreed upon scientific goals and objectives of national and worldwide importance
  - Program distributed to bring in all interested and capable parties.
  - Program is designed to break into clean interface parts that can be split among parties without massive management overhead.

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- Energy Cost
- Hunger
- Pollution Control
- Climate Vagaries
- Poverty
- Literacy
- Health Maintenance
- Nationalism
- Taxes
- Jobs
- Atmosphere Control
- Crime
- Motivation of the Young

There are many areas in which the SEI can benefit the world. Rather than attempt to cover all of them, we have selected the concerns shown in Table 5 for this presentation. It is our contention that goals can be set that will effect the technology push for SEI and, in turn, influence scenarios.

Low-Cost Non-Polluting Energy

The world has finally recognized that we are polluting our nest. We have also begun to use energy at a prodigious

Table 5. Space Exploration Initiative Examples of Concern-Driven Architectures World Goals Approach

Concern	SEI Strategy	Architecture Effect
Low-cost, non-polluting power	Utilize DOE to pursue power and propulsion beyond NERVA and Rover	Fusion for Mars; solar or electric propulsion; lunar solar electric power; potential He_3 mining and fusion power
Low water, low pesticide plant growth	Emphasize Closed-Cycle Ecological System Development	Push plant growth solutions in SSF and moon for Mars
Pollution – waste and water control	Closed-loop ECLS development first on SSF and moon	Water and waste management recycling systems
AIDS or aging	Emphasize immune system breakdown research	Early experiments on SSF and the moon prior to Mars

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rate. There has been a demonstrated connection between the cost of energy, its availability, and a nation's standard of living. Long-term clean energy sources must be researched to provide for our own future needs as well as other nations. Energy sources are an important part of the environmental thrusts. Nuclear research is progressing but does not promise near-term solutions and the developed nations are reaching a plateau of power availability. The emerging nations need power but the damage to the environment caused by burning fossil fuels is greater than the risks of nuclear energy. Currently the U.S. consumes about 2.8 trillion kWh of electrical energy. If this rate grows at only 2% per year, by 2050 U.S. power requirements will be around 9 trillion kWh. The total world needs, even assuming low usage by the developing nations, easily exceed an estimated 20 trillion kWh by the 2050 time period. With attendant tripling of nonnuclear systems, such as hydroelectric power to avoid fossil fuel system proliferation, nuclear power systems usage will have to increase by a factor of 6 to meet requirements. This later in the face of a rising discontent with the environmental effects of current nuclear energy waste disposal and some plants being converted to fossil fuels rather than nuclear. A clean, renewable source of energy must be found and implemented. Space can hold solutions to this problem if we are politically and economically willing to reach for them.

Three of these potential sources are described in the NASA Lunar Enterprise Case Study. Helium 3, Solar Power Satellites (SPS), and a Lunar Power System (LPS) all have significant feedback potential to other applications besides the obvious benefit of an unlimited clean energy source. These three potential solutions are the subject of a NASA TM. This report, TM 101652, discusses the Solar Power Satellite and Lunar Power System and describes a potential Helium 3 endeavor.

Low Water, Low Pesticide Plant Growth; Waste and Water Purity Control

The two items listed here represent major concerns of most of the developed part of our planet and are emerging concerns in the developing nations. Our problems on earth of raising enough food to feed our exploding population in concert with growing water shortages and a growing realization that our current pesticide methods are radically polluting bring great emphasis to the need for a technological revolution. Our fast disappearing garbage dump areas and the problems of water control and reuse have spawned whole new industries in the last few years.

While previous short duration manned space programs have been able to depend on open-loop life support systems, SEI cannot. NASA in their 90-Day Report and many subsequent studies have identified an evolutionary path from present systems through the partial regenerative Space Station Freedom (SSF) approach that will recycle only oxygen and water and depend on logistics resupply to provide other consumables, spares, and waste management. The path then continues on through progressive development of a closed cycle physical chemical extension of the SSF approach finally culminating in a bioregenerative system. It is not clear that intermediate steps really save in the longer view. We realize, as does any good system engineer, that the reduced resupply requirements must be traded against system cost, power requirements, volume, reliability, maintainability, and limitations of other resources. Reaching for the Controlled Ecological Life Support System (CELSS) may well lead to world benefits far beyond a less challenging approach.

Areas of emphasis in the CELSS approach are mentioned in Table 6. It can be seen by inspection that many of the long-term and pressing short-term world problems can be approached by reaching for the stars. It is interesting to note that Shimizu, a member of the McDonnell Douglas SEI group is most interested in bioregenerative systems for one predominant reason—the potential of a solution to Tokyo's waste management problems.

Human Physiology–Aging–AIDS

Many of the current human problems are the result of changes or failures of the body's natural immune system.

Table 6. Critical CELSS Development Areas Combined with Advanced Physical and Chemical

Plant Growth in Controlled Environment ■ Select crop plants for nutritional value and productivity ■ Optimize and control plant growth response ■ Develop support systems to allow healthy growth in closed chambers	**Plant Growth in Low-g (Reduced or Micro)** ■ Study crop plant productivity with microgravity as worst case ■ Determine ability of support systems to function in microgravity ■ Perform multiple-generation studies in space radiation and low-g environment
Waste Processing & Nutrient Recovery ■ Develop energy efficient waste processor to convert plant and human waste into plant nutrients and water ■ Develop biomass processor to convert some portion of inedible plant materials into dietary supplements	**Plant Growth in Controlled Environment** ■ Develop a laboratory system to investigate microbial interactions and toxicology ■ Determine control strategies to provide a stable reliable life support system
Atmosphere Revitalization ■ Develop technology for makeup nitrogen generation ■ Remove CO_2 reduction by-products ■ Improve trace contaminant control and monitor	**Water Management** ■ Eliminate urine pretest chemicals ■ Regenerate or eliminate post-treatment filter and sorbent beds ■ Improve quality monitoring

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We are able to diagnose many of these effects and have made great strides in ameliorating the symptoms, but to date the function of the immune system has defied understanding.

Both U.S. (84 day) and Soviet (300 day) missions have evoked similar red blood cell and immune system changes. Hematological and immunological changes observed during or after space missions have become quite consistent. Decreases in red blood cell mass were reported in Gemini, Apollo, Skylab, and Soyuz programs, probably due to diminished rates of erythrocyte production. Space flight at micro-g levels may involve changes in white blood cell morphology and a compromise of the immune system. Skylab studies indicated a decrease in the number of T-lymphocytes and some impairment of their function. Some U.S. and Soviet findings suggest that space flight induces a transient impairment in the function of the immune system at the cellular level. Some data from the Soviet year-long missions suggest a complete breakdown of the immune system. These changes disappeared post-flight within 3–4 weeks.

The space flight arena offers a clinical laboratory unlike any place on earth to understand the function of the human immune system. Perhaps cures for aging, AIDS, and other immune function-related illnesses can result from proper use of the space laboratory and the investigation into the human long-term reaction to space.

Another physiology effect has also arisen lately that may effect both space travel and earthbound people. Several of the ideas promulgated during the recent outreach endeavor have drawn comparisons between hibernating animals and space flight effects. Bears, for instance, appear to utilize pathways of physiological mechanisms to prevent loss of calcium from bones into urine and feces and loss of lean body mass as reflected by nitrogen in urine. A new chemical isolation technique has been developed which has isolated unique substances associated with these pathways. It is not unreasonable that these same substances will have a positive influence in preventing loss of bone calcium and lean body tissues in the human while at low-g conditions. This research may have potential for treating osteoporosis, kidney disease, and management of burns and trauma in humans.

Space is a laboratory from which we may well develop synergistic cures for many of man's illnesses as byproducts of our eventual human trip to Mars.

Scenario Comparisons

Table 7 shows three potential scenarios that could describe SEI. If the first two more conventional thought processes are compared to Number 3, the MAXBACK approach, the data in Table 8 can be derived to compare the feedback to jobs, education, economics, and world goals of the future. It is claimed here that the MAXBACK approach which is specifically designed to develop technologies with the greatest feedback potential is worth closer investigation. The role of SEI in solution of world-wide problems is summarized in Table 9.

Summary

A series of conclusions and recommendations can be made from our analysis. These are listed in sequence below.

Conclusions

■ The U.S. needs high technology developments to strengthen its industries to become more competitive internationally.

■ A main reason for the U.S. aerospace industry's dominance in international trade is technology developments spurred by NASA and other government agencies.

■ Space program funding is an investment into the American economy creating thousands of jobs and billions of dollars both directly and indirectly.

■ Technology developed for space applications to date has had reasonable spin-off potential, but it is clear that most technologies were single-purpose oriented and not a part of an overall feedback plan.

Table 7. Space Exploration Approaches

1. Flags and Footprints	2. Minimum Approach	3. MAXBACK
■ Land humans on Mars and return safely ■ Apollo-type mission ■ Few (about 3) human missions to Mars for 30 days with limited scientific observations and surface analysisp ■ Utilize available technology where possible–only minimum new thrusts ■ Discontinue effort after human landings ■ Precede human landings with robotic missionsnUtilized moon and SSF as test-beds for human Mars mission	■ Utilize moon to demonstrate habitats, rovers, life sciences, and operations ■ Lunar stay times 30-90 days in human tended emplacements ■ Utilize common transfer vehicles and surface equipment for lunar and Mars missions ■ Stay time on Martian surface 30-90 days with about 8 months in Mars orbit ■ Limited development of in situ or closed cycle systems ■ Precede human landings with robotic missions	■ Utilize moon and SSF as test-bed for Mars, but design for eventual permanent lunar and Mars emplacements ■ Utilize in situ resources for construction, propulsions, life support ■ Implement closed loop and Controlled Ecological Life Support Systems –100% self sufficiency ■ Utilize artificial gravity in transfer systems ■ Develop in situ lunar and Mars power systems ■ Utilize robotics extensively for probes, sample return, site identification, and surface operation

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Table 8. Exploration Options Comparison

Research Area	Option 1	Option 2	Option 3	Comments
Artificial Gravity	4	3	1	Serious research of this nature will only be done for programs seeking its use. MAXBACK will force this research and Minimum Approach may require limited studies
Small Nuclear Power Systems	3	3	1	All options may utilize some type of RTG, but MAXBACK will require SP-100 class nuclear reactors
Artificial Intelligence	3	2	1	All options will need a measure of artificial intelligence with dependence increasing as mission demands increase
Robotics and Teleoperation	3	2	1	Again all options will need advances in this technology, but MAXBACK relies most heavily on robotics for base construction and surface operations
Life Sciences	2	1	1	Significant advances must be made before any trip to Mars, or long duration exposure to varying g levels, radiation, etc., is attempted
Computer Systems	3	2	1	Highest computer demands are for options relying most heavily on robotics and automation
1 atm Space Suit	2	1	2	All options will benefit from a 1 atm EMU, with Minimum Approach needing it most. MAXBACK seeks to reduce EVA time by using robotics and teleoperation instead
Macroengineering	3	2	1	MAXBACK is a definite macroengineering management challenge as it is the most involved and seeks to utilize many players
Mechanical Systems	2	1	1	Improvements in the efficiency and reliability of mechanical systems is required for all options
CELSS	4	3	1	Ability to produce food is key to becoming self-sufficient. Minimum Approach may have limited need for CELSS, but MAXBACK requires the capability
ECLSS	2	2	1	Monitor and control of life support systems will be imperative for each option, with highest demands for MAXBACK
Alternate Power Sources	4	4	2	Only MAXBACK has long term goal for determining construction methods for potential space-based power systems
Materials Processing	4	3	1	Again only MAXBACK utilizes in situ resources for propulsion, life support, construction, etc, as a mission requirement
TOTALS	39	29	15	

Summary
In terms of the greatest potential payoff to the public through technology development, the option with greatest need for research, and thus lowest total, is superior. The "Flags and Footprints" option requires little new technology and will not significantly benefit the taxpayers outside of the aerospace community. The Minimum Approach Scenario is better, but MAXBACK is specifically designed to develop technologies with the greatest economic feedback potential.

Legend: Technology Development Required
1 = Extensive 2 = Moderate 3 = Little 4 = None

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Table 9. National and World-Wide Problems and Goals: The Role of SEI

Conclusions

- Technological advances resulting from space activities can positively effect world needs if programs are designed with this in mind.
- The general public must be informed as to how space related activities benefit them; past, present, and future.
- One of the best ways to garner political support for a particular program in a certain area is to direct attention to the resolution of community needs (i.e. stressing jobs created in areas suffering from high unemployment).
- There is a direct relation between space program success and nationalistic pride.
- SEI planning must be open-minded to ideas of all participants, domestic and international.

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- The space program, as seen during the Apollo program, has a direct effect on motivating students to seek advanced technical degrees.
- The number of students seeking engineering and science degrees have decreased steadily leading to shortages in all U.S. industries.
- Distributing SEI research programs to many areas of the country is very possible when utilizing government facilities, contractors, and universities.
- Previous developments in space technology have significantly contributed to our standard of living.
- Many technologies needed for SEI can be utilized to alleviate some of the world's most pressing problems.
- A clean, renewable source of global energy may determine our environmental fate as well as provide for our ever increasing needs.
- More demanding and ambitious exploration scenarios require more research and technology development therefore, have more potential for feedback.
- Many areas of SEI R&D can have significant feedback potential.

Recommendations

- SEI research dollars should focus on developing technologies with greatest feedback potential.

- Exploration programs should be long-term with built-in evolutionary growth, which enable continuing research.

- Near- and long-term goals must be clearly defined before an initiative enters research phase.

- Keeping the interest of the general public high is imperative throughout the course of SEI to help garner political support. This can be done by use of phased programs with achievements such as rovers and sample return missions to Mars and the Moon.

- Motivate young people to achieve engineering and science degrees by stressing the role they can play in the space program now and throughout their careers with near- and long-term goals.

- The general public must be educated as to how the space program benefits them in terms of jobs, money, education, new and better products and, also the costs of space exploration in comparison to other government programs.

- An exploration program focused on return to taxpayers is also one with a goal of permanent human presence in space and continuing exploration of the solar system. The Space Exploration Initiative is an opportunity to explore our solar system and better the world for ourselves and future generations.

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