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SPACE EXPLORATION AND
THE BENEFITS TO MANKIND

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ABSTRACT

Exploring the unknown and pushing toward new frontiers is a natural drive for humans. This drive has resulted in discoveries that have provided for a longer and better quality of life for most people on our planet. Until the middle of this century, physical exploration had been limited to the earth, and the discoveries have had tremendous impacts on everyone — both positive and negative.

Although space exploration is in its infancy, the discoveries — including technology advancements and spin-offs — have continued to improve life on earth. This paper discusses some of the endeavors and discoveries of space exploration and what they have meant for improving life on earth.

- Weather observation satellites save thousands of lives each year
- Communication satellites have enabled an information exchange that has resulted in a "smaller world" and political freedom for more people.
- Satellites have enabled disarmament agreements to be verified.
- International partnership in space endeavors have resulted in better understanding and cooperation among various countries.
- Advancements in materials and electronics have made many consumer

items more compact, lighter and faster.

These and other impacts are amplified in this paper.

Common causes have created multi-national bonding. In the past, the many causes have been related to defense against aggression from other nations (e.g., the North Atlantic Treaty Organization); the enhancement of trade and finances (e.g., the World Bank); relief from natural disasters (e.g., the 1989 Armenian earthquake); rescue in human emergencies (e.g., the mission of Apollo 13); and the pursuit of space endeavors (e.g., the European Space Agency). Because of the global nature of space systems, future space exploration will continue to encourage nations to work more closely to overcome the resistance of nature and to muster the resources for venturing further into space and for longer periods of time.

The challenges of space exploration are so great and require the expertise of so many disciplines in a multi-national effort (lawyers, educators, engineers, scientists, economists, doctors, historians, writers) that the cooperative effort, if done properly, can advance all disciplines and help assure world peace.

This paper analyzes the past challenges of the space program's multi-national cooperative agreements and examines the challenges of the future as we quickly become a global society.

Many of the technologies, skills and capabilities that were developed for military purposes — from mathematics, science, computers, power, propulsion, communications and operations to management — are directly applicable to space exploration. We must harness these resources, excite our youth to strive for better education and advance the technologies in order to explore space and further bond the countries of the world. This truly can mean "peace and progress through space."

INTRODUCTION

Thirty-three years after the launch of the space age, much has been written about the benefits of the space program.

The foundation for working and living in space has been laid, and many operational systems are in place. We have begun to understand how to utilize an environment that had for so long appeared alien to mankind. We have mastered new technology and successfully built the mechanisms to define, explore and operate in space. We have successfully journeyed with space equipment and humans to near-earth orbit and to the moon. Business has turned a tidy profit through the commercialization of spaceflight equipment. Certainly, massive amounts of new information about space itself, the earth and the solar system have been accumulated and are being studied. A whole new field of scientific study and a global industry has been set in place, together with a new stream of education, management and global facilities to carry out their objectives.

One might still question the value of this endeavor. While it is true that profits have been made, the investment — to date — has far exceeded the material return

one might expect in an undertaking of this scope. Some of the greatest expectations have not been realized; nor do they seem much closer than they were 33 years ago.

However, one cannot use profit as the only criterion. We must evaluate the benefits of space not only in material result, but for the aesthetic, political, educational and other less tangible contributions that are made to the quality of our life on earth.

It is the purpose of this paper to address both direct and indirect benefits of space exploration, define the framework within which we now operate and evaluate where we stand and what we expect for the future. It is timely that this subject be considered by the Symposium on Space and Education.

SPACE EXPLORATION: THE MORAL EQUIVALENT OF WAR

Throughout history, many of mankind's greatest advancements have been stimulated by exploration. Fundamentally, these missions have been motivated by the desire to make a profit, to conquer or to defend one's security, or to satisfy an intellectual curiosity. Often, there have been additional motives: to introduce religion (a form of conquest), to avoid overcrowding (a form of the profit motive) or to achieve (a form of intellectual curiosity).

Many great ideas were conceived during these missions, but often lay dormant until a major event stimulated sufficient resources and authority to ensure success. For example, the early development of automotive transportation, submarines, electronic communications and aviation occurred in the early 1900s, but proceeded at a slow pace until World War I. The dictum of military needs then stimulated further progress of these technologies. Not only did technology development for a specific system accelerate, but growth of the supporting infrastructure advanced.

This was observed in the early 1920s with the dramatic growth of fuel production facilities, the automobile industry and road systems were needed to support the rapid application of the automobile. At the same time, the field of aviation suddenly expanded. During a time of international conflict and subsequent government investment, the building of airports and development of commercial aviation stimulated the field of aerospace technology.

That stimulation not only helped resolve problems during war time, but resulted in huge benefits for the future. The USA's civil and military aircraft industry sales projected for 1990 are \$137 Billion. Total commercial airline revenue for American flag carriers was \$69 billion in 1989. The success of supporting services and industries multiplies that amount.

In addition to the economic benefits, we were provided with relative safety and time savings. In the early 1900s, travel from New York City to London by ship took seven days. Today, that same trip takes approximately three hours on the supersonic Concorde aircraft. And the chances of a passenger being killed on a five-hour commercial flight across the USA is only one in 11 million. By contrast, the odds are one in 916,666 by train and one in 14,200 by automobile.

In addition to the end systems developed as a result of the war's stimulation, a myriad of technologies, techniques, new products and — more important — a new understanding of what could be achieved were spread throughout the world. New opportunities appeared and new pathways were cleared; still, many technological ideas stalled — lacking the support to set rapid progress in motion.

In the field of endeavor vital to this Congress, for example, at the beginning of WWII, no spaceflight existed. For that matter, the jet aircraft had not yet been invented and senior advisory groups were attempting to persuade most na-

tional leaders not to develop the gas turbine. Likewise, no powerful rockets existed — though techniques on an experimental basis were being explored. The critical support elements of spaceflight — computers, transistors and microelectronics, inertial navigation systems, lasers — were missing, along with the educational base and industry or management systems needed for such a program.

But again, with the massive effort unleashed during World War II, these and many other fields were stimulated and — for the first time — stimulated in a highly organized manner. As is the case in military efforts, it was not always necessary to show an immediate profit, and supporting efforts were carried along by the war-time stimulus. The consolidation of this research in the post-World War II era is well-known:

- The massive expansion of television
- The growth of global jet travel
- The new benefits of medical research
- The impact of the computer
- The growth of educational systems to cope with this new society and
- As a precursor to today's space systems — the development of long-range ballistic missiles.

In the Cold War period of the late 1940s and early 1950s, the competitive effects of war continued to stimulate technological development in both the USA and in Europe. New technology was quickly applied to modernizing old weapons systems and creating new ones.

During the 1950s, however, the element of exploration was superimposed on existing military systems. With the emergence of the International Geophysical Year (IGY) came the bold proposal that, with the new ballistic missile technology, the USA and Soviet Union undertake development of rocket-boostered earth satellites to explore near-space and take earth science measurements from space. This spurred international competition dedicated to peaceful objectives.

Exploration of space, then, became the "moral equivalent of war" in its ability to stimulate technological advances.

The rest, as they say, is history. Not only were the International Geophysical Year objectives obtained, but scientists and entrepreneurs around the world began to recognize the virtue of developing this new technology. At this point, all the elements of a major thrust toward new frontiers were in place — security, exploration and the profit motive. On both sides of the Atlantic, visionaries quickly laid out plans and programs to push this challenge forward.

In the USA, President John F. Kennedy and the Congress created new agencies to manage the space effort and new industries to support development; acquired massive facilities to manage, test, build and operate new space systems; and established new educational programs and facilities to develop the new skills required for a future in space.

Seldom has a concept for the future had such a massive impact on a nation as did the evolution of the American space program in the 1960s. The successful execution of a manned lunar landing in 1969 captured the imagination and spirit of every man, woman and child. Nearly a decade of nationwide malaise — marked with the assassinations of the Kennedy brothers and Martin Luther King, the Vietnam War and student unrest on college campuses — ended on a triumphant note of success and progress.

The lofty objective set forth by President Kennedy at the beginning of the decade had been achieved. And along with it came the vital stimulation to education and technology. The tools of space exploration brought new ways of maintaining peace, understanding and "one world." They also introduced global communications, weather, navigation and surveillance systems — connecting all parts of our shrinking world.

SATELLITES: COMMUNICATION AND DATA COLLECTION

Due directly to the space program and its network of communication satellites, we can see and hear what is happening in real time in most places on earth. Sports and other major events around the world are enjoyed by millions of people simultaneously. Disasters and human suffering are witnessed and responded to, usually within hours. Isolated areas in countries such as India and Indonesia — previously unable to establish intranational communications because of the high cost of cable installations — have been connected by television.

During the past year, millions of people around the world have fought for more freedom and the opportunity for better lives — lives similar to those they witness through information brought by digital communications and satellites. Never again will people be denied information by which to help themselves determine their destiny.

That information could have saved at least 6,000 people who were killed in 1900 by a hurricane in Galveston, Texas. But hurricane warning systems were inadequate at that time. Today, all hurricanes are predicted, identified and tracked by satellite information throughout their life spans. Analytical models using other satellite weather data are used to predict the path and areas that will be affected, and the wind velocities, tidal surges and rainfall that will accompany the storm. The benefit: Each year, thousands of lives are saved and millions of dollars worth of property damage is avoided.

In the future, a better understanding of the process and conditions that cause weather will lead to more accurate predictions of tornadoes, flash floods, high winds and drought — predictions that may save more lives, property and resources.

Already, satellite technology is responsible for the location and rescue of downed aircraft and distressed ships. Equipped with a tiny emergency transmitter, a downed aircraft, for example, emits a constant signal that is picked up by satellite and relayed to a monitoring ground station. With these data, the location of the downed aircraft can be quickly ascertained and rescue action undertaken. To date, hundreds of rescue missions on land and sea have been undertaken on an international basis.

MEDICINE: A BETTER QUALITY OF LIFE

The miniaturization of electronic components for use in space has been a boon for modern medicine and, therefore, meant longer and richer lives for people here on earth. While this is one of the least recognized benefits of the space program, there are many examples of medical advances that grew from space-based technologies.

The insulin infusion pump, a device that uses microprocessors and small, long-life batteries to deliver a continuous and prescribed dose of insulin, eliminates the diabetic's need for shots and the resulting varying level in the bloodstream.

Image enhancement techniques pioneered by earth resource projects are used to interpret magnetic resonance images of the body, making it possible for physicians to map the body and make earlier diagnoses of problems such as tumors or blood clots.

The modern hospital nursing station began with a contract to develop an astronaut monitoring system. Now the computerized systems allow centralized monitoring of patients.

In addition, space technology has resulted in lightweight wheelchairs, one-handed control mechanisms for handicapped drivers, voice-controlled wheelchairs, speech autocurers, im-

plantable defibrillators, high-speed dental drills, dental braces and scratch-resistant plastic for eyeglasses.

REMOTE SENSING: MONITORING OUR EARTH

Satellite remote sensing also has enabled us to keep an eye on the long-term health of our planet. With the view that global problems require a global perspective, scientists have used the technique since 1970 to monitor ocean productivity, worldwide biological activity and the hole in the earth's ozone layer.

This very limited but dramatic information has enabled scientists to identify key global change processes that can be monitored on a continuing basis. In order to enhance the prediction and management of change, the government created the U.S. Global Change Research Program. Its goal is to gain a predictive understanding of the interactive physical, biological, geological and social processes that regulate the total Earth system and, hence, establish the scientific basis for national and international policy formulation and decisions relating to natural and human-induced changes in the global environment and their regional impacts.

By listening to astronauts and viewing the stunning photographs of their missions, we have begun to recognize the fragility of our planet's environment and the dramatic effects of changes to it. Further use of space exploration-derived capabilities and advancements can help us to understand and protect the environment for future generations.

Scientists concerned with the better management and use of our earth's resources also seek the vantage point of space. A multitude of sensors have been developed to gather imaging and full-spectrum energy emission data of the Earth from space. This data is converted into information — often computer-enhanced — to determine the size and health of various types of crops and

vegetation, help locate various types of ocean fish and determine ocean conditions, and to find minerals, water and other natural resources below the Earth's surface.

The benefit to commercial entities has been more efficient planning, reduced search time and fuel savings; and governments have been able to establish policies and plans for monitoring land and sea use.

NAVIGATION SATELLITES: SAFER TRANSPORTATION

The use of earth satellites for the navigation of ships, aircraft and other earth vehicles was one of the earliest successful applications of space technology for practical benefit.

The early development of the US TRANSIT system for ship navigation in 1962 was followed by a worldwide expansion of its use. This system, which reported the location of a ship in feet rather than miles, was a gigantic step toward eliminating collisions and groundings. In less than two decades, there were more than 20,000 shipboard installations on ships flying the flags of more than 60 nations. In addition, the know-how for manufacture of shipboard navigation receivers was made available, resulting in more than 15 nations building this equipment. Development is continuing with new technologies such as the Global Positioning System, which extends this capability to aircraft, mobile land vehicles and even passenger cars — all with increased accuracy and greater coverage.

ARMS CONTROL VERIFICATION: PEACEFUL COEXISTENCE

Earth observation satellites have been used by both the east and the west in monitoring military action. The "big eyes in the sky" have made it difficult for significant movements of military troops or equipment to be secretly accomplished. Satellite information signals

early alerts of these movements, curtailing potentially dangerous situations. Satellites have also been a valuable and effective means of helping to verify arms treaty agreements.

INDIRECT BENEFITS OF SPACE EXPLORATION:

Although we have realized many direct benefits from the technologies associated with space exploration, there have been equally valuable indirect benefits. These social, philosophical and spiritual benefits cannot be measured quantitatively. But they have added to the quality of our existence.

Humans become closer when they work together for a common cause — and even closer when they accomplish their objectives. Exploring space has provided the catalyst for nations of the world to work together, regardless of differences in man-made laws and political motivations.

Some dramatic cooperative space ventures of the past, such as the USA-USSR Apollo-Soyuz mission of the 1970s, provided giant steps toward mutual understanding and significant easing of international tensions — perhaps more than any other action during that decade.

An outgrowth of that mission was an uninterrupted USA-USSR cooperative program in space medicine and bio-astronautics, which resulted in an outstanding achievement during the recent Armenian earthquake. During the tragedy, the USA and the Soviet Union utilized satellites with tele-medicine equipment to bring the services of hundreds of doctors to the region. During an unprecedented mission, these doctors were able to treat patients via satellite.

Despite our technological advances, humans continue to explore. As infants, we test all our senses to satisfy our thirst for knowledge. Children later explore

through reading, and a whole new world is discovered.

It is difficult to maintain this exploring spirit in education. The rewards may not be as fulfilling or immediate as they were when we were infants. But the excitement of space exploration — witness the popularity of Star Trek — does provide motivation for learning mathematics and the physical sciences. These are the enabling skills for reaping the rewards of space accomplishments. There has been a strong correlation between enrollment in mathematics, engineering and physical science courses and space exploration activities in the USA. We must capitalize on this driving force for more education in these fields, which will lead to more technology and a better quality of life for everybody.

There has been much to enable students to experience first-hand the thrills of space exploration and further increase their desire to continue their education. Student experiments are conceived in schools and carried into space to be executed. This began in the USA during the Skylab program and continues today on space shuttle flights -- space shuttle Columbia's recent tomato-seed program really gave school children direct participation.

On the shuttles, students have had 22 experiments flown on 13 missions. The real benefit is that these experiments programs have involved approximately one million students. Get-Away-Specials (GAS) cannisters allow simple and expedient integration of student experiments on the shuttle

Youth exploration adventures in the USA used to be limited to troops of Boy Scouts and Girl Scouts at summer camp. Today, these educational opportunities still exist, but there have been new opportunities for exploration — from computer camps to space camps. At the Space Camp in Huntsville, Ala., last year, there were approximately 20,000 young people who

experienced the thrill of space mission planning, training and simulations. Most of these students will more aggressively pursue their studies when they return to school.

Higher education is stimulated by graduate student fellowships, the U.S. Research Associates and the International Space University, where last year more than 100 students from over 20 countries met in Strasbourg, France, to earn college credit while working on a joint space design project.

Perhaps no single worldly endeavor is so free of conflict and embodies objectives that are so admired on a global basis than the field of space exploration and utilization.

Certainly, space has been a mighty tool in our quest to build one world.