Chapter IV

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"Ultimately, Europe's success on earth will partly depend on its success in space".

- Carl Bildt, former Swedish PM

This statement, though made by a European and referring to Europe, holds true for all other countries on the earth as well. Most people think of NASA and scientific exploration when they think of space. However, operations in outer space are currently chasing commercial targets on a considerable scale, as evidenced by the ever increasing activities on the satellite launching pads. Fierce competition is going on between the USA, Europe, Russia and China, a competition intensified by China accepting lower launching fees than the other states or organizations concerned. Such commercial activity has been strongly encouraged and supported by the leading powers in space technology, the USA and Russia.

There is a great deal of money being made in space by companies providing commercial services such as telecommunications, satellite navigation, earth observation, and space transportation. Some of the benefits of a commercial nature are particularly spectacular and significant in the field of telecommunications and remote sensing, e.g. broadcasting by satellite. The immense benefits this facility can have, say for isolated communities, cannot be over-emphasized, some of them being agriculture, education, medical aid, health and hygiene, family planning, etc. Other benefits involve scientific research and exploration of outer space, the Moon, Mars and other celestial bodies, including the outlook for exploitation of resources in these new areas. The potentialities created by outer space operations are being used more and more for commercial gain.

The main commercial space application of telecommunications & broadcasting is globally a £40 billion sector today and is dominated by private sector organisations. In fact, the Satellite Industry Association estimates that world revenues in the commercial space industry exceeded $65 billion in 1998[1]. In fact the US has established a separate Office of Space Commercialization at the Commerce Department which has been operating since 1988.

Space tourism has the potential to emerge as one of the first space industries and pave the way for others. The first steps will just be short sub-orbital flights, like Alan Shepard made in 1961, since these are easier than getting to orbit. But the technical know-how to make passenger launch vehicles and orbiting hotel accommodation is available, and there is enormous unsatisfied demand - market research has revealed that most people, at least in the industrialized countries, would like to take a trip to space if it is possible. This gives huge scope for reducing the cost of space travel by large-scale operation like airlines. More affordable suborbital space tourism is viewed as a money-making proposition by several companies, including Space Adventures, Virgin Galactic, Starchaser, Blue Origin, Armadillo Aerospace, XCOR Aerospace, Rocketplane Limited, the

[1] *www.sia.org*

European "Project Enterprise", among others. Most of these companies are proposing vehicles that make suborbital flights peaking at an altitude of 100-160 km. Passengers would experience three to six minutes of weightlessness, a view of a twinkle-free star field, and a vista of the curved Earth below. Projected costs are expected to be about $200,000 per passenger.[2]

Virgin Galactic, one of the leading potential space tourism groups, is planning to have passenger service on its first spaceship, the VSS Enterprise (Scaled Composites SpaceShipTwo). The spaceships used will go 360,000 feet (109.73 km or 68.18 miles) high; this goes beyond the height of 100 km, which is the internationally defined boundary between Earth and space. Space flights will last 2.5 hours, carry 6 passengers, and reach a speed of Mach 3[3]. SpaceShipTwo will not require a space shuttle-like heat shield for atmospheric re-entry as it will not experience the extreme aerodynamic heating experienced during re-entry at orbital velocities.

4.1 Phases of Space Tourism

Any business that is begun goes through various stages of development in the course of its growth. Similarly, once space tourism gets started it will also develop progressively. It may be assumed that it will go through several phases. Starting with a relatively small-scale and relatively high-priced "pioneering phase", the scale of activity will grow and prices will fall as it matures. Finally it will become a mass-market business, like aviation today.

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[2] *http://en.wikipedia.org/wiki/space_tourism*
[3] *http://www.spacefuture.com*

Pioneering phase

The phrase "space adventure travel" has been suggested by Gordon Woodcock of Boeing[4], and is a convenient one to describe the first phase. Customers will be relatively few - from hundreds per year to thousands per year; prices will be high, perhaps in the range of about $50,000 and upwards; and the service will be nearer to "adventure travel" than to luxury hotel-style. Orbital accommodation will be safe but simple and basic.

Mature phase

This will see demand growing from thousands of passengers per year to hundreds of thousands per year. Tickets to orbit will cost less and flights will depart from many different airports. Orbital facilities will grow from being just clusters of pre-fabricated modules to large structures constructed in orbit for hundreds of guests, permitting a range of orbital entertainments.

Mass phase

Ticket prices will fall to the equivalent of a few thousand dollars, and customers will grow from hundreds of thousands to millions of passengers per year. Apparently unthinkable to most people in the space industry, even one million passengers per year is just eight hours of aviation! And aviation is still growing fast at today's level of one billion passengers per year. So there is no reason to suppose that space travel will ever stop growing. There is certainly no limit to the

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4 *http://www.spacefuture.com*

possible destinations. And the access to space resources that low cost launch will bring about will ensure that economic growth need not end for a few more millennia at least!

The main obstacle is simply the conservatism of the space industry as it is today. Since Sputnik was launched in 1957 most space activities have been funded by governments. And this "cold war" pattern of space activities has created an image of space that colours everyone's thinking about it - writers, journalists, politicians, scientists and engineers, and the general public. Even science fiction writers assume as obvious that most space activities will always be government activities.

4.2 Government v. Private Enterprise

The first explorations into uncharted territory, from Lewis and Clark to the Apollo missions, are usually funded, directed, and managed by the government. These projects are pure research by their very nature: high risk with uncertain results. Return voyages, however, are best done by entrepreneurs. They are better at developing transportation hardware, and they have the marketplace incentive to provide affordability and adequate safety.

Powered flight did not need to go through the government-funded stage, since it was lone entrepreneurs who succeeded in the important pioneering efforts. They quickly followed with solutions for business activities: air shows within six years, barnstorming within 14 years, airmail flights within 15 years, and competitive airline service within 23 years of the first flight of the Wright Brothers.

Spaceflight took the more traditional path. Governments directed and funded all the research and conducted all the initial flights. Then, for forty three years, all manned flight activity outside the atmosphere was the exclusive domain of government programs. The Russians have sold several seats on their Soyuz rockets, but this has been done because of a financial need rather than as a part of any plan to commence passenger flight operations.

On the Earth, governments provide a number of services, defence, police, and a legal system. But most activities are private, which are done by individuals and companies. It is going to be the same in space. After the end of the Cold War, space agencies' budgets were cut. So far, instead of using their huge funding to try to develop a profitable business like space tourism, the agencies were continuing the same activities, even though taxpayers were not so interested any more.

However, the general public is very interested in travelling to space for themselves. So after some false starts in the 1950s, 60s and 80s, work towards realizing the dream of space tourism is finally beginning to gather some momentum. It is most probable that this dream will come true this time, for several reasons. Some of these reasons include the following:

- Because people want it
- Because it is a realistic objective
- Because it is the only way in which space activities can become profitable
- Because it is the quickest way to start to use the limitless resources of space to solve our problems on Earth

- Because living in space involves every line of business, from construction to marketing, fashion, interior-design and law
- And last but not the least - Because it will be fun!

Developing low-cost passenger launch vehicles is not just for the purpose of creating a pastime for the rich. In business, the companies that make big money are the ones that serve big markets. Like tourism on Earth, there will be a small expensive segment for the rich and well-to-do. But the great majority of space tourists will be middle-class customers – the greater majority of us.

But utilizing space depends on access. Until access is cheap, we can't make use of the limitless resources available in space to solve the problems of our ever-more-crowded Earth. But once access becomes cheap, we can start utilizing the boundless resources of space for the benefit of earthlings. And to make it cheap we need large turnover. Tourism can generate the large-scale launch activity needed to reduce costs sufficiently to start to use space resources, and so space tourism has become one of the most important projects in the world today.

Commercial space activities today include satellites being used for communications, broadcasting and photography (remote sensing). But these are small businesses – no more than a few billion dollars per year – that will never need humans in space. So "commercial space activities" today are not leading towards space tourism. Consequently specific efforts need to be made to set up space tourism services, because they won't happen as a natural consequence of present-day space activities.

Some people believe that developing space tourism is very difficult, so it will take a long time and it should be left to the government space agencies. But the agencies already spend $25 billion per year on "space activities", and they are not trying to develop launch vehicles that could open up space to the public. A miniscule percentage of their budget is used for this purpose - although even just one year of their huge funding would be plenty!

Instead of working towards enabling the public to travel to space, government space agencies carry out a range of activities, a large part of which involves developing and operating wholly or partially expendable launch vehicles. These are not profitable in the normal sense of the word; indeed they return none of the investment in their development to taxpayers. Furthermore, these vehicles are not leading on to the development of profitable or passenger-carrying vehicles; and their operation has little relation to the operation of future passenger space vehicles. Work that is specifically devoted to reusable launch vehicles is confined to unpiloted satellite launchers.

The International Space Station (ISS) on which space agencies plan to spend some $100 billion of taxpayers' money over its lifetime, is an inter-governmental project which will not be profitable, and of which the cost and operations are not a useful model for a commercial facility. In addition, the legal environment is quite different from what is required in a commercial facility and is not appropriate to a commercial passenger industry.

It thus appears that space agencies have chosen to define their role not to include enabling the general public to travel to space and back. However, by taking this position, space agencies are thereby threatening their own futures, choosing to make themselves increasingly irrelevant to the taxpayers who fund them. The growing urgency of this problem is well exemplified by a recent discussion about the lack of missions requiring the space shuttle after the assembly of the International Space Station, and the statement by the US President that he considers that "...benefits to us here on Earth" are more important to the US public than the Mars mission favoured by NASA's leaders[5].

The lack of interest of the space agencies in aiding the development of passenger space travel services reflects their history as organisations set up during the Cold War to carry out government projects. Their viewpoint contrasts with that of customer-oriented commercial organisations, and is indeed predictable from the theory of the self-interested behaviour of government agencies developed by organization theorists. It begs the question whether the space agencies now serve a valuable public purpose, in the absence of economic benefits arising from their activities in the form of wealth-creating commercial space activities. Scientific research has a value other than its economically measurable value, but this represents only about 10% of space agencies' activities.

Since the end of the Cold War, many industries have experienced vigorous restructuring, which is still continuing as consolidation occurs on a global scale. The space industry has also seen some restructuring, notably consolidation of large aerospace companies due to cuts in defence budgets, and commercialisation of satellite communications activities. But the pattern whereby government funding dominates essentially 100% of human space flight activities remains unchanged.

[5] *http://www.nasa.gov/*

The 20th century ended with many important industries that the 19th century had not even envisioned. Air transport, automatic household appliances, radio, television, movies, computers and electronics, wireless telephony, underwater work systems, and the Internet all emerged as significant engines of economic growth, newly created wealth, and improved living standards. Yet although the so-called Space Age has occupied more than a third of the past century, manned space activity has not emerged as a new industry to stand beside these others in its impact on our daily lives. This can be attributed partly to the technical complexity of operating in space, but it also cannot be denied that the economic environment has not provided, and still does not provide, the right conditions for entrepreneurial activity. Entrepreneurial activity may be broadly defined as private initiatives that develop into new commercial products and services. The participation to date of most private companies in the manned space program, even start-up companies, has not met the test of commercial activity. To be commercial in the full sense means to invest significant amounts of private funds, to put them at risk to develop privately owned capital assets that form the basis for offering products and/ or services into a market in which price is based on an agreed value.

Most private-sector investors have so far focused on more earthly pursuits than investing in space related prospects. Only one thing would prod them into the cold, hard vacuum of space, and that is the prospect of earning cold, hard cash. This scenario is now changing with not only governments spending more than ever on space programmes but also private players entering the field, thus heralding the commercialization of space activities. Worldwide government spending on space is estimated to be around $50 billion a year, a 25% jump over 2000. NASA represents only $16 billion of that total, but during the next 20 years, the U.S. space agency is likely to sign contracts totalling as much as $400 billion to launch a human mission to mars.[6]

In 1998, private-sector spending on space applications began to exceed government spending, and the gap is widening. Some of the prospective businesses being pursued by private entrepreneurs such as suborbital tourism, space hotels and solar satellites have the potential to generate astronomical returns during the next decade.

Space tourism is an idea whose time has come. It is going to start soon, and it is going to grow rapidly, generating the funds needed to open up space to a wide range of human activities.

4.3 Private Space Flights

Since ancient times, mankind has always desired to be able to fly like birds in the sky. This desire was to a certain extent fulfilled with the invention of aircraft. But since aircraft have a limited range, this achievement of flying in the sky only fuelled a new desire, i.e. to be able to go still higher into space. However, until now, access to space by human beings has generally been the sole province of astronauts and cosmonauts utilizing government developed and operated space transportation systems and orbital facilities. For space travel to become affordable and available to the general public, the private sector must become engaged to develop and operate commercial space transportation systems and orbital facilities. Experience and technical data pertaining to the development and operation of human-qualified

[6] *Chris Taylor, 'Profits set to soar in outer space', Business 2.0 Magazine, 27 February 2006*

space transportation systems and orbital facilities need to be acquired by those private entities wishing to enter the space tourism sector and to develop it as a new area of commerce.

Private space flight is flight above 100 km (62 m) conducted by and paid for by an entity other than a government. In the early decades of the Space Age, the government space agencies of the Soviet Union and United States pioneered space technology in collaboration with affiliated design bureaus and private enterprises. Later on, large defence contractors began to develop and operate space launch systems, derived from government rockets, and commercial satellites. Private space flight in Earth orbit includes communications satellites, satellite television, satellite radio and orbital space tourism. Recently, entrepreneurs have started designing and flying suborbital space planes. Planned private spaceflights beyond the Earth's orbit include solar sailing prototypes, deep space burial and personal spaceflights around the Moon. A private orbital habitat prototype is already in Earth orbit, with larger versions to follow.

During the early years of spaceflight only nation states had the resources to develop and fly spacecraft. Both the U.S. space program and Soviet space program were operated using mainly military pilots as astronauts. During this period, no commercial space launches were available to private operators, and no private organization was able to offer space launches. Eventually, private organizations were able to both offer and purchase space launches, thus beginning the period of private spaceflight.

The first phase of private space operation was the launch of the first commercial communications satellites. The U.S. Communications Satellite Act of 1962 opened the way to commercial consortia owning and operating their own satellites, although these were still launched on state-owned launch vehicles.

On 26th March, 1980, the European Space Agency created Arianespace, the world's first commercial space transportation company. Arianespace produces, operates and markets the Ariane launcher family. By 1995 Arianespace launched its 100th satellite and by 1997 the Ariane rocket had its 100th launch. Arianespace's 23 shareholders represent scientific, technical, financial and political entities from ten different European countries[7].

From the beginning of the Shuttle program until the Challenger disaster in 1986, it was the policy of the United States that NASA be the public-sector provider of U.S. launch capacity to the world market. Initially NASA subsidized satellite launches with the intention of eventually pricing Shuttle service for the commercial market at long-run marginal cost.

On 30th October, 1984, the then United States President Ronald Reagan signed into law the Commercial Space Launch Act. This enabled an American industry of private operators of expendable launch systems. Prior to the signing of this law, all commercial satellite launches in the United States were limited to NASA's Space Shuttle.

On 5th November, 1990, the then United States President George H. W. Bush signed into law the Launch Services Purchase Act. The Act, in a complete reversal of the earlier Space Shuttle monopoly, ordered NASA to purchase launch services for its primary payloads from commercial

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[7] *http://en.wikipedia.org/wiki/Private_spaceflight*

providers whenever such services were required in the course of its activities.

Commercial launches outnumbered government launches at the Eastern Test Range in 1997.

4.4 Emerging Personal Spaceflights

Before 2004 no privately operated manned spaceflight had ever occurred. The only private individuals to journey to space went as space tourists in the Space Shuttle or on Russian Soyuz launch vehicle flights to Mir or the International Space Station.

All private individuals who flew to space before Dennis Tito's self-financed International Space Station visit in 2001 had been sponsored by their home governments. Those trips include US Congressman Bill Nelson's January 1986 flight on the Space Shuttle Columbia and Japanese television reporter Toyohiro Akiyama's 1990 flight to the Mir Space Station.

The Ansari X PRIZE was intended to stimulate private investment in the development of spaceflight technologies. The 21st June, 2004 test flight of SpaceShipOne, a contender for the X PRIZE, was the first human spaceflight in a privately developed and operated vehicle.

On 27th September, 2004, following the success of SpaceShipOne, Richard Branson, owner of Virgin and Burt Rutan, SpaceShipOne's designer, announced that Virgin Galactic had licensed the craft's technology, and were planning commercial space flights in two and a half to three years. A fleet of five craft is to be constructed, and flights will be offered at around $200,000 each, although Branson has said he plans to use this money to make flights more affordable in the long term.

In December 2004, United States President George W. Bush signed into law the Commercial Space Launch Amendments Act. The Act resolved the regulatory ambiguity surrounding private spaceflights and is designed to promote the development of the emerging U.S. commercial human space flight industry.

On 12th July, 2006, Bigelow Aerospace launched the Genesis I, a subscale pathfinder of an orbital space station module. Genesis II was launched on 28th June, 2007, and there are plans for additional prototypes to be launched in preparation for the production model BA 330 spacecraft.

On 28th September, 2006, Jim Benson, SpaceDev founder, announced that he was founding the Benson Space Company with the intention of being the first to market suborbital personal spaceflight launches with the safest and lowest cost, using the vertical takeoff and horizontal landing Dream Chaser vehicle based on the NASA HL-20 Personnel Launch System vehicle.

4.5 The Economic Viewpoint of Space Tourism

During its first century, aviation has grown from the Wright brothers' tiny "Flyer" to become a globe-spanning activity which has changed the world we live in. However, after more than forty years, space travel remains very different from aviation – whereas air travel is a huge, privately operated activity as it started, thanks to the Wright Brothers, space travel remains a government monopoly activity as it started, in the USSR back in 1961. Based on market research showing enormous potential demand, engineers have prepared conceptual designs of passenger vehicles, and have reached the consensus that a passenger vehicle capable of regular flights to and from low Earth orbit could be developed for less than the amount that G7 governments' space agencies spend every year[8]. With such a development, tourism could grow to become the largest activity in space, leading to a genuine "aerospace" industry and a renaissance of space activities. However, this requires civilian space activities to change to follow the economically successful model of aviation centred on commercially operated passenger travel services.

Over the past half century, taxpayers of the world have paid nearly $1 trillion for civilian space activities, with approximately half of this amount being spent on human space flight. If the same investment were made on a commercial basis, it would be generating revenues of several hundred billion dollars per year, employing more than ten million people on a permanent basis, and earning tens of billions of dollars per year of profits. However, although telecommunications and broadcasting satellites are now commercially self-sustaining activities, they generate about $20 billion per year in revenues, and human space flight activities earn only a few tens of millions of dollars per year.

Development of commercial passenger travel services to and from space is the key innovation needed to generate an economic return on the cumulative investment made in space capabilities until today. It is

[8] *Collins, Patrick, "Space Tourism, Market Demand and the Transportation Infrastructure", 2003*

technically feasible using existing technology, and it is expected to grow into a much larger business than satellite communications. In addition it will have important macro-economic impacts by helping to overcome the current global deflation caused by world-wide over-capacity in older industries and insufficient innovation of new ones. Governments currently spend $25 billion per year on civilian space activities, but essentially none of this is aimed at realizing passenger space transportation. Facilitating the application of space technology to the development of passenger space travel services should be a priority of economic policy.

4.6 Collaboration with Aviation

Passenger space travel is much nearer in the future than is widely believed to be, at least in the form of sub-orbital passenger flights to space, to an altitude of 100 km and above. In this form, the first private space flights could start within a few years, and thereafter commercial passenger flights will start as soon as legal and regulatory issues permit.

In order to develop safe and profitable passenger travel services to, from and in orbit, companies and organisations with experience of space activities have a great deal to benefit from cooperation with companies and organisations in the aviation industry, which has decades of experience of operating advanced aerospace systems profitably and with a high level of safety. Thus vigorous collaboration with the aviation industry in developing passenger space travel services offers the best prospect of putting space activities on a commercial basis.

To date, government-funded space agencies have declined to embrace this fact. If this state of affairs continues, it would be economically beneficial for government funding of space agencies to be reduced, and for funding of appropriate aviation research to be increased, with the specific task of developing passenger space travel services. For governments not to be actively aiding development of this new field of business is a serious and costly mistake of economic policy, and the sooner that it is corrected the better for economic growth worldwide.

The US government's Commercial Space Act of 1998 and commitment to commercialize the International Space Station's operations have changed the direction of space development in the post-Cold War years. During 1998 also the feasibility and great economic potential of space travel by the general public was acknowledged in publications by NASA, AIAA (American Institute of Astronautics and Aeronautics) and the Japanese Federation of Economic organizations (Keidanren)[9]. However, crewed space activities are all taxpayer-funded, primarily for scientific research; they have involved only a few hundred people travelling to space till date; and those involved have no experience of commercial passenger service operations.

By contrast, aviation is a global industry which is largely commercial, involving a wide range of activities from engineering design to marketing, and serving more than one billion passengers every year. Aviation has very high safety levels developed over decades of experience of carrying billions of passengers. Furthermore, the aviation industry also has extensive experience of operating rocket-powered piloted vehicles – during the 1950s several countries operated

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[9] *http://www.spacefuture.com*

such vehicles sufficiently frequently to develop routine operations, maintenance and repair procedures.

The explosion of the 'Challenger' in 1986, after 24 consecutive shuttle flights, grounded all U.S. manned space missions for more than two years. If this is compared with the early history of aviation, it can be seen that when 20 of the first 40 pilots hired by the Post Office died in crashes within three years, there was no suspension of service. Since the Columbia tragedy in 2003, spaceflights have seemed more hazardous than the pioneering ones of the 1960s. Now, 45 years after cosmonaut Yuri Gagarin first orbited the Earth, spaceflight remains horribly risky: one fatal crash in every 66 flights. The risk of dying in an airliner during early scheduled operations was about one in 6,000 flights. Within three years it had improved to one in 33,000 flights. Today it is one in several million[10].

Consequently, in order to develop safe and profitable passenger travel services to, from and in space, people, companies and organisations with experience of space activities have a great deal to gain from collaboration with all parts of the aviation industry. Due to the potential economic value of this development, and the high cost to taxpayers of space activities today, governments should take steps to start this collaboration as soon as possible.

The Federal Aviation Administration, i.e. the FAA's Associate Administrator for Commercial Space Transportation has started to develop a clear, long-term vision of a vigorous, commercial space tourism industry that is lacking in the government-dominated space industry.

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[10] *http://www.spacefuture.com*

Regarding Space Traffic Control, in 1998 the FAA started a study of extending air traffic control to include vehicles in low Earth orbit (LEO) and travelling between Earth and LEO, in order to create a seamless system accommodating both air and space vehicles. This led to the publication of a draft report on this subject in 1999. This report is genuinely path-breaking, proposing a range of initiatives and tackling key issues needed to realise space travel by the general public.

4.7 Space Transition Corridors

A particularly significant proposal in the above mentioned report that was published as a result of the study conducted by the FAA, is that of "Space Transition Corridors" (STC) - zones linking an area on the ground to an area in orbit reserved for either a vehicle returning from orbit or a launching vehicle, into which other aircraft are not permitted for the duration. This proposal resolves the potential problem that a returning vehicle such as Kankoh-maru will not be able to carry sufficient fuel to be able to manoeuvre significantly within the atmosphere before landing. For example it will not be able to hover for several minutes, nor reroute to another landing site as scheduled airliners can. Kankoh-maru's pilot will therefore need to receive irrevocable permission to land at its planned destination airport before departing from the orbiting hotel to which it is docked.

The concept of STC solves this problem elegantly: it is not a permanent fixed route like an air-lane, but a temporary zone defined in space and time within a computerised air traffic control system. As such it enables efficient and economical use of airspace and orbital space.

Details of such a system remain to be decided, and it will require international support to become an international standard.

4.8 International Space Flight Organisation

The FAA has also proposed the formation of a new organisation, the International Space Flight Organisation (ISFO) to play the role of the International Civil Aviation Organisation (ICAO) with respect to passenger space travel. The ISFO would help to coordinate different countries' activities and ensure that agreement is reached on international procedures and standards in a timely manner. For example, non-US governments have yet to comment on the FAA's proposal of STCs, as they are behind the USA in making plans for the advent of reusable launch vehicles capable of round-trips between the Earth and space. The ISFO could help to make international progress in this matter.

Seen from the point of view of aviation, space tourism is much nearer in the future than is widely appreciated within the space industry - at least in the form of sub-orbital passenger flights to space, to an altitude of 100 km and above. Vehicles capable of such flights could start operations within just a few years, and thereafter commercial passenger flights will start as soon as the regulatory process allows. Overall, the idea of passenger space travel seems readily accepted within aviation.

4.9 Future Plans

Just as airmail contracts from the Post Office spurred the development of civil aviation a century ago, a market for civilian spaceflight could also be nurtured by contracts with the private sector to deliver cargo into orbit. Prize money, which was the incentive that launched Charles Lindbergh[11], a US Air Mail pilot, is now being offered for everything from building a machine to extract oxygen from lunar soil ($250,000 is the amount offered) to building an aircraft capable of delivering tourists to orbit by 2010 ($50 million).

Energy from space

Future energy development may use energy sources in space and on other planets. Examples include Helium-3 extraction from the Moon, and solar power satellite systems.

Asteroid mining

The long-term possibilities are even more celestial. Some have speculated on the profitability of mining metal from asteroids. According to some estimates, a one km diameter asteroid would contain 30 million tons of nickel, 1.5 million tons of cobalt and 7,500 tons of platinum; the platinum alone would have a value of more than $500 billion at current prices.[12] While the potential rewards from asteroid mining are indeed huge, the technical challenges are equally large and it seems likely that the private sector will wait for the publicly funded space program to solve them (e.g. by establishing experimental mines on the Moon).

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[11] *US Air Mail Pilot, solo non-stop flight from New York to France in a single-seat, single-engine monoplane, 'Spirit of St. Louis', May 1927*

[12] *http://en.wikipedia.org/wiki/Private_spaceflight*

One of the rocks that are found in space is about 2 km in diameter named 3554 Amun that looks as if it might have fallen straight out of The Little Prince[13]. There are three key things to know about 3554 Amun: First, its orbit crosses that of the Earth; second, it is the smallest M-class (metal-bearing) asteroid yet discovered; and finally, it contains roughly $8 trillion worth of iron and nickel, $6 trillion worth of cobalt, and $6 trillion worth of platinum like metals[14]. In other words, whoever owns Amun could become 450 times as wealthy as Bill Gates. And if the journey is timed right – the year 2020 looks promising – it is easier to reach than the Moon. But that does not mean that it is easy, because everything that is worthwhile has taken decades to reach its full potential like the automobile, the desktop computer, the mobile phone, commercial air travel, to name a few.

There are many speculations as to where private spaceflight may go in the near future. One possibility is for paid suborbital tourism on craft like SpaceShipOne. Additionally, suborbital spacecraft have applications for faster intercontinental package delivery and passenger flight. SpaceX's Falcon 9 rocket, scheduled to be first launched in mid 2008, is designed to be man-rated. This would be the first American orbital vehicle since the Space Shuttle to receive this designation, in principle allowing the vehicle to transport paying customers to orbit. Plans and a full-scale prototype for the SpaceX Dragon, a manned capsule carrying up to 7 passengers, were announced on March 6, 2006.[15]

An early flight of the Falcon 9 is planned to carry the prototype expendable space complex module (based on the formerly NASA-owned

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13 *'The Little Prince', French aviator Antoine de Saint-Exupéry, 1943*
14 *Collins, Patrick, "Space Tourism, Market Demand and the Transportation Infrastructure", 2003*
15 *http://en.wikipedia.org/wiki/Private_spaceflight*

Transhab design) constructed by Bigelow Aerospace. Bigelow Aerospace expects such modules to be used for activities like microgravity research, space manufacturing, and space tourism (with modules serving as orbital hotels). To promote private manned launch efforts, Bigelow has offered the 50 million dollar America's Space Prize for the first US-based privately funded team to launch a manned reusable spacecraft to orbit on or before January 10, 2010.

XCOR Aerospace plans to initiate a suborbital commercial spaceflight service with the Lynx rocketplane in 2012. First test flights are planned for 2010. Excalibur Almaz plans to launch a modernized Almaz space station, for tourism and other uses. It will feature the largest window ever on a spacecraft.

4.10 On-orbit Propellant Depots

In a presentation given on 15th November, 2005 to the 52nd Annual Conference of the American Astronautical Society, NASA Administrator Michael D. Griffin suggested that establishing an on-orbit propellant depot is, "Exactly the type of enterprise which should be left to industry and to the marketplace". At the Space Technology and Applications International Forum in 2007, Dallas Bienhoff of Boeing made a presentation detailing the benefits of propellant depots.

4.11 Space Elevators

The space elevator is enabled by the advent of lightweight carbon nano tubes. A 62,000-mile elevator to the heavens would reduce orbital freight costs by 98% and open up space just as the railroads opened up the Wild West.

A Space Elevator system is a possible launch system, currently under investigation by at least one private venture. There are concerns over cost, general feasibility and some political issues. On the plus side the potential to scale the system to accommodate traffic would be greater than some other alternatives, at least in theory. Some parties assert that if a space elevator is successful, it would not supplant existing launch solutions, but instead it would complement them.

4.12 The 62,000-Mile Elevator Ride

A foggy office parking lot in Mountain View, California was the setting for the first Space Elevator Games, sponsored by NASA, which offered a $200,000 prize to the first team that could make a machine climb up a 164-foot tether, powered by nothing but a mirror and a beam of light from a 10,000-watt bulb. None of the home-brewed contraptions on display could reach higher than 40 feet.

The theory behind the elevator is simple. First proposed more than a hundred years ago by a Russian scientist, it was popularized by Arthur C. Clarke in his award-winning 1978 novel, 'The Fountains of Paradise', and goes like this: Earth is constantly spinning. So if a counterweight is attached to it with a cable, and it is put far enough away – 62,000 miles – the cable will be held taut by the force of the planet's rotation, just as if a person spins around while holding a ball on a string. And if you've got a taut cable, you've got the makings of an elevator.

A working elevator would reduce the cost of launching anything into space by approximately 98%. The $500 million it takes to launch an average satellite, not including insurance, would be a thing of the past.

The cable, known to elevator scientists as a ribbon, would be dropped in stages from space and hooked up to a floating platform similar to an offshore oil rig. An elevator car about the size of a Boeing 747, able to carry hundreds of people or 200 tons of cargo, could climb and descend the ribbon at a speed of 120 miles per hour. That means the first trip to geosynchronous orbit (22,000 miles) would take seven days, but scientists estimate that it could be reduced to four days by the time the first passengers make the journey.

Not only would an elevator reduce launch costs, but it would increase the amount of cargo capacity for orbital trips. More than 90% of the space shuttle's weight is fuel, with cargo making up less than 5%. On the elevator, fuel is not necessary, because the car would be electric, with power cells energized by a ground-based laser beam.
The reason why anyone has not tried to build one yet is because the material needed for the ribbon didn't exist until now. Until 1991, no substance came close to being strong, lightweight, and durable enough to do the job. Then a Japanese scientist stumbled on an arrangement of carbon atoms that became the strongest material ever tested – carbon nano-tubes. Nano-tubes are about 100 times stronger than steel, yet they weigh only a fifth as much as steel.

A carbon nano-tube string having the width of sewing thread could easily lift a large car. A nano-tube elevator ribbon would need to be no thicker than plastic food wrap. Nano-tubes would also make the elevator car light, though large.

A handful of companies worldwide, like Carbon Nanotechnologies in Texas, Mitsui in Japan, and Nanoledge in France, are already producing purified nano-tubes. The longest nano-tubes yet produced measure only a few inches, but that doesn't prevent them from being

ribbon-ready. The nano-tubes themselves don't need to be 62,000 miles long, they can be bonded or joined together, just as cotton fibres aren't long enough to make a shirt, but are bonded together.
The real problem is their cost. At $500 per gram, nano-tubes are currently too expensive, and worldwide production is estimated to be less than 100 pounds per day.

The Chinese government has made no secret of its ambitious space program and carbon nano-tube research. Nor has Japan. Whoever builds the first elevator will have a virtual monopoly on all future ones. The political and economic structure of the world could be completely different 50 years from now. Risk to the infrastructure would be minimum. The floating platform would most preferably be anchored on the equator, which is the Earth's calmest area with the fewest lightning strikes and storms. The ribbon will have the highest melting point of any material ever produced and be flexible enough to withstand high winds.

On the question whether the space elevator would be a giant cargo freighter to the stars, or would tourists also be able to enjoy the ride, there is scepticism about the commercial viability of space tourism. Still, it is estimated that for about $20,000 per person, a group of as many as 30 could go up in the elevator for eight hours, reach reduced gravity, see the curvature of Earth and the sky darken in the daytime, have a picnic, and come down. It might not be the thrill ride that U.S. businessman Gregory Olsen took in a Russian shuttle last year, but he paid $20 million. This would be for the price of a Toyota Camry.

In the meantime, NASA's Centennial Challenges are focused on the power-beaming and tether-climbing aspects of the elevator. Competition, the agency believes, is the best way to drive applications for technology that already exists. The next Space Elevator Games will be a far cry from the homemade robots struggling up a few feet of tether. NASA has increased the prize money to $400,000 from the $2,00,000 offered the first time round, and 45 teams have already signed up.

4.13 Future of Space Travel

Space tourism is increasingly being covered by the media. The concept is gaining increasing acceptance in public perception. Market research in Japan, America, Germany and Britain has revealed a strong public demand for space travel, even at relatively high prices.

It is widely understood that the growth of space activities is constrained by the very high price of launch due to the use of expendable or dispensable vehicles, and that Reusable Launch Vehicles (RLVs) must be developed in order to sharply reduce the cost of access to space. But it is not so widely understood that the main obstruction to the development of RLVs is neither technology nor cost but market factors – it is not economical to spend billions of dollars to develop a reusable vehicle for launching satellites, because the satellite launch market is too small to recover such a large investment.

Hence the question arises as to what is the potential of passenger space travel to grow to the scale of commercial aviation. Recent developments in the US and elsewhere indicate that there is a new wave of entrepreneurial activity in the space industry. This includes the creation of Bigelow Aerospace, Virgin Galactic Airways, and the recent formation of MirCorp as a joint US/Russian venture to rescue and refurbish the Mir space station as a tourist destination.

Space activities are still a heavily subsidized and government-funded activity. Space activities will become self-supporting only when the development of an independent commercial space industry is made a core objective of government space funding.

The development of a passenger space travel industry requires collaboration between space and aviation bodies, including companies, research institutions, and regulatory authorities. This process should start with the development and operation of sub-orbital passenger space travel services.

Until SpaceShipOne's three flights in 2004, there were no entrepreneurs actively testing spaceflight hardware in order to solve the issues of cost and safety. Now there are plans to develop a fleet of suborbital spaceships within the next decade. Competing orbital resort hotels and "shore excursions" – swings around the Moon will probably be offered to space tourists in the future. When space travel becomes driven by profit, activities such as energy generation, mining, and medical research will flourish. It is possible that after about a period of 300 years, people who go to other planets may not return. They may stay, raise their families, and provide insurance for the survival of our species. This would necessarily involve the concept of space colonization.

4.14 Space Colonization

Space colonization is a colossal science that includes all of the scientific disciplines needed to be able to build colonies on non-Earth planets and planetoids. Also called space settlement, space humanization, space habitation, etc., it is the concept of autonomous or self-sufficient human occupation of locations outside the earth. It is a major theme in science fiction; it is also a long-term goal of various national space programs. While many people think of space colonies on the moon or mars, others believe that the first colonies will be in orbit. They have determined that there are ample quantities of all the necessary materials on the Moon and on asteroids that are near the earth, and that solar energy is readily available in very large quantities.

The longest human occupation of space so far has been the space station Mir which was continuously inhabited for almost ten years including the record single spaceflight of Valeri Polyakov who stayed in space for almost 438 days. Long-term stays in space reveal concerns with bone and muscle loss in low gravity, immune system suppression and radiation exposure.

Many past and current concepts for the continued exploration and colonization of space focus on a return to the moon as a "stepping stone" to the other planets, especially Mars. At the end of 2006 NASA announced that they were planning to build a permanent moon base with continual presence by 2024.

In 2005 NASA Administrator Michael Griffin identified space colonization as the ultimate goal of current spaceflight programs, saying:

"... the goal isn't just scientific exploration ... it's also about extending the range of human habitat out from Earth into the solar system as we go forward in time ... In the long run a single-planet species will not survive ... If we humans want to survive for hundreds of thousands or millions of years, we must ultimately populate other planets. Now, today the technology is such that this is barely conceivable. We're in the infancy of it. ... I'm talking about that one day, I don't know when that day is, but there will be more human beings who live off the Earth than on it. We may well have people living on the moon. We may have people living on the moons of Jupiter and other planets. We may have people making habitats on asteroids ... I know that humans will colonize the solar system and one day go beyond"[16].

As of 2008, the International Space Station provides a permanent, yet still non-autonomous, human presence in space. The NASA Lunar outpost, providing a permanent human presence on the moon, is at the planning stage. There is an ongoing development of technologies that may be used in future space colonization projects.

4.15 As on Earth, so in Space – Building Space Colonies

Human habitation in space is an inevitable prospect for the future. Building colonies in space will require access to food, space, people, construction materials, energy, transportation, communications, life support systems, simulated gravity, and radiation protection. Hence, the colonies that would be established would in all probability be situated in such a way that they would help in fulfilling those requirements.

Colonies on the Moon and Mars could use local materials, although the Moon is deficient in volatiles (mainly hydrogen, and nitrogen) but possesses a great deal of oxygen, silicon, and metals such as iron,

[16] *http://en.wikipedia.org/wiki/Space_exploration*

aluminium and titanium. Launching materials from the Earth to the Moon would be very expensive, so bulk materials could come from the Moon, a Near-Earth Object (NEO) such as an asteroid or a comet with an orbit near Earth, Phobos or Deimos where gravitational forces are much smaller, there is no atmosphere, and there is no biosphere to damage. Many NEOs contain substantial amounts of metals, oxygen, hydrogen and carbon. Certain NEOs may also contain some nitrogen.

Solar energy in orbit is abundant and reliable, and thus it is routinely used to power satellites today. There is no night in space, and there are no clouds or atmosphere to block sunlight.

In the weightless conditions of space particularly, sunlight can be used directly, using large solar ovens made of lightweight metallic foil so as to generate thousands of degrees of heat at apparently no cost; or reflected onto crops to enable photosynthesis to continue unhindered.

Large structures would be needed to convert sunlight into significant amounts of electrical power for the use of settlers in space colonies. Energy has been suggested as an eventual export item for space settlements, perhaps using wireless power transmission e.g. via microwave beams to send power to the Earth or the Moon. This method has zero emissions, so it would have significant benefits such as the elimination of greenhouse gases and nuclear waste. The ground area required per watt would be less than what is required for the conventional solar panels.

The Moon has nights of two Earth weeks in duration and Mars has night, dust, and is also farther from the Sun, reducing solar energy available and possibly making nuclear power more attractive on these bodies. For both solar thermal and nuclear power generation in airless environments, such as the Moon and space, and to a lesser extent the very thin Martian atmosphere, one of the main difficulties is dispersing the heat that is inevitably generated. This requires fairly large radiator areas. Alternatively, the waste heat that is generated can be used to melt ice on the poles of a planet like Mars.

Transportation to orbit is frequently the limiting factor in space endeavours. To settle in space, much cheaper launch vehicles are required, as well as a way to avoid serious damage to the atmosphere from the thousands, perhaps millions, of launches required. One possibility is the air-breathing hypersonic space plane under development by NASA and other organizations, both public and private. There are also proposed projects such as building a space elevator or a mass driver; or launch loops.

As compared to the other requirements, communication is moderately easy for orbit and for the Moon. A large percentage of current terrestrial communications already passes through satellites. Yet, as colonies further from the earth are considered, communication becomes more of a burden. Transmissions to and from Mars would suffer from significant delays due to the speed of light and the greatly varying distance between conjunction and opposition — the lag will range between 7 and 44 minutes. This would necessarily make real-time communication impractical. Other means of communication that do not require live interaction such as e-mail and voice mail systems would not pose any problems.

People need air, water, food, gravity and reasonable temperatures to survive for long periods. On Earth, a large complex biosphere provides these requirements of life. In space settlements, a relatively small, closed ecological system must recycle or import all the nutrients without "crashing". The closest terrestrial analogue to space life support is possibly that of the nuclear submarine. Nuclear submarines use mechanical life support systems to support humans for months without surfacing, and this same basic technology could probably be employed for space use.

Location is a frequent point of contention between space colonization advocates. The location of colonization can be on a physical body or free-flying:

- On a planet, natural satellite, or asteroid
- In orbit around the Earth, Sun, Lagrangian point or other object

There is a suggestion that Mercury could be colonized using the same technology, approach and equipment that is used in colonization of the Moon. Such colonies would almost certainly be restricted to the Polar Regions due to the extreme daytime temperatures at other places on the planet. Scientists have been astonished by the recent discovery of ionized water on Mercury. This discovery significantly improves the small planet's prospects as a future colony.

Due to its proximity and relative familiarity, the Earth's Moon is also frequently discussed as a target for colonization. It has the benefits of proximity to Earth and lower escape velocity, allowing for easier exchange of goods and services. A major drawback of the Moon is its low abundance of volatiles necessary for life such as hydrogen and carbon. Water ice deposits that may exist in some polar craters could serve as a source for these elements. An alternative solution is to bring hydrogen from near-earth asteroids and combine it with oxygen extracted from lunar rock.

The moon's low surface gravity is also a concern because it is unknown whether 1/6g is sufficient to support human habitation for long periods.

4.16 A Kitchen Garden on the Moon

Whatever may be the arguments for and against colonizing the moon, an Arizona company is taking definite steps in the direction of future colonization and preparing for future settlers. From the freeze-dried powders and semi-liquid pastes of decades ago, US scientists are now trying to grow vegetables in mini-greenhouses on the moon. Residents of future lunar or even Martian outposts will be dining on luxuries such as fresh vegetables in the future.

Paragon Space Development Corporation has unveiled what it called the first step toward growing flowers, and eventually food, on the moon. 'Lunar oasis', as it is called, is a sealed greenhouse that looks like a bell jar encased in a 1.5 foot tall triangular aluminium frame. It is designed to safely land a laboratory plant on the lunar surface, and protect it while it grows. The miniature greenhouse is to be launched into space by Odyssey Moon Ltd., a participant in the Google Lunar X prize. This competition offers $20 million to any entrant who can launch, land and operate a Rover on the lunar surface[17].

The future testing of the lunar oasis is dependent on the flight schedule of the Odyssey, which will be 2012 at the earliest. The greenhouse will contain seeds of Brassica, a hardy plant related to Brussels sprouts and cabbage and used in the production of cooking

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[17] *The Times of India, Bangalore edition, dt.16.4.09*

oil and livestock feed. Because Brassica goes from seed to flower in just 14 days, it can complete its life cycle in a single lunar night.

A good analogue to conditions at a lunar outpost can be provided by the conditions at the South Pole, which include a high-altitude, low air pressure environment, and wind-chill factors of -100° C. The South Pole greenhouse, now in its fifth year, allows workers living in the coldest place on earth to dine on tomatoes, peppers, lettuce, strawberries and fragrant herbs. There are many challenges to growing plants in space, but the biggest challenge is finding enough water on site to support a permanent outpost.

4.17 Free Space Locations : Orbital Colonies

Free space locations in space would necessitate a space habitat, also called space colony and orbital colony, or a space station which would be intended as a permanent settlement rather than as a simple way station or other specialized facility. They would be literal "cities" in space, where people would live and work and raise families. Many design proposals have been made with varying degrees of realism by both science fiction authors and engineers.

A space habitat would also serve as a proving ground for how well a generation ship could function as a long-term home for hundreds or thousands of people. Such a space habitat could be isolated from the rest of humanity for a century, but it could be near enough to Earth for help. This would test if thousands of humans can survive a century on their own before sending them beyond the reach of any help.

Compared to other locations, Earth orbit has substantial advantages and one major, but solvable, problem. Orbits close to Earth can be reached in hours whereas the Moon is days away and trips to Mars take months. There is ample continuous solar power in high Earth orbits, whereas all planets lose sunlight at least half the time. Weightlessness makes construction of large colonies considerably easier than in a gravity environment. Astronauts have demonstrated moving multi-ton satellites by hand. 0g recreation is available on orbital colonies, but not on the Moon or Mars.[18] Finally, the level of (pseudo-) gravity is controlled at any desired level by rotating an orbital colony. Thus, the main living areas can be kept at 1 g, whereas the Moon has 1/6 g and Mars 1/3 g. It is not known what the minimum g-force is for ongoing health but 1 g is known to ensure that children grow up with strong bones and muscles.

The main disadvantage of orbital colonies is lack of materials. These may be expensively imported from the Earth, or more cheaply from extraterrestrial sources, such as the Moon (which has ample metals, silicon, and oxygen), Near Earth Asteroids, comets, or elsewhere.

Outside the solar system

Looking beyond our solar system, there are billions of potential suns with possible colonization targets.

Physicist Stephen Hawking has said:

'The long-term survival of the human race is at risk as long as it is confined to a single planet. Sooner or later, disasters such as an

[18] *g-force of an object is its acceleration relative to free-fall. An acceleration of 1 g is equal to standard gravity.*

asteroid collision or nuclear war could wipe us all out. But once we spread out into space and establish independent colonies, our future should be safe. There isn't anywhere like the Earth in the solar system, so we would have to go to another star.'[19]

4.18 Objections to Space Colonies

The main objection to colonizing space is that it will be expensive. Colonizing space would require massive amounts of financial, physical and human capital devoted to research, development, production, and deployment. While the total costs may be unknown, even maintaining the current budget of NASA is politically challenging in the US.
Even if the technology were available, and the costs of deploying a program relatively low, and the likelihood of success relatively high, only a small number of people would directly benefit from a colony (either enthusiastic colonists or high risk commercial interests), leaving most of the financing of the program to the public.

The fundamental problem of public goods, such as space programs, is the free rider problem. Convincing the public to fund such programs would require additional self-interest arguments. If the objective of space colonization is to provide a "backup" in case everyone on Earth is killed, then why should people living today on Earth pay for something that is only useful after they're dead? This assumes that space colonization is not widely acknowledged as a sufficiently valuable social goal.

Other objections include concern about creating a culture in which humans are no longer seen as human, but rather as material assets.

[19] *http://en.wikipedia.org/wiki/Space_colonization*

The issues of human dignity, morality, philosophy, culture, bioethics, and the threat of megalomaniac leaders in these new "societies" would all have to be addressed in order for space colonization to meet the psychological and social needs of people living in isolated colonies or generation ships. Although they are not being utilized yet, cultural anthropologists may have something to offer to the space programs.

As an alternative or addendum for the future of the human race, many science fiction writers have focused on the realm of the 'inner-space', that is the computer aided exploration of the human mind and human consciousness.

4.19 Favouring Space Colonies

There are some factors in favour of establishing space colonies, whether on other planets or in orbit, which are discussed below-

The need factor

The population of Earth continues to increase, while its carrying capacity and available resources do not increase proportionately, in some cases not increasing at all. If the resources of space are opened to use and viable life-supporting habitats can be built, the Earth will no longer define the limitations of growth. On the other hand, extrapolations made using available figures for population growth, show that the population of Earth will stop growing around 2070.

Furthermore, even if humanity manages to avoid devastating the Earth through war, pestilence, pollution, global cooling, global warming, and even cometary impacts, the Earth will ultimately become uninhabitable by the heating of the Sun as it ages. If humanity has not made permanent habitations in space by the time any one of these incidents occurs, it may very well go extinct.

The cost factor

Very many people greatly overestimate how much money is spent on space, and underestimate how much money is spent on defence or social programs. If we take into consideration military spending, for example, as of 2008, over $845 billion has been spent by the USA on the current war in Iraq. In comparison, it only cost $2 billion to create the Hubble Space Telescope, and NASA's annual budget averages only about $16 billion. In other words, the money that has been spent on the Iraq war could have theoretically funded NASA for approximately 52 years.[20]

Or consider Social Spending Programs of the USA. The United States government spends about $581 billion on its Social Security program, an additional $561 billion on Medicare, plus additional monies on other social programs whose budgets lie within the bounds of the "Other Discretionary Spending" category of the Federal Budget. This means that the United States spends more than $1.142 trillion on social programs per year, which is equal to more than $3,807 per person per year. In comparison, the United States space program costs a mere $53 per person per year[21].

[20] *http://en.wikipedia.org/wiki/Space_colonization*
[21] *ibid*

The benefits factor

Cynics and critics of the development of permanent space colonies and infrastructure often refer to the very high initial investment costs of space colonies and permanent space infrastructure, but they ignore all potential returns on that investment. The long-term vision of developing space infrastructure is that it will provide long-term benefits far in excess of the initial start-up costs. Therefore, such a development program should be viewed more as a long-term investment and not like current social spending programs that incur spending commitments but provide little or no return on that investment.

Because current space launch costs are exorbitantly high, any serious plan to develop space infrastructure at a reasonable cost must include developing the ability of that infrastructure to manufacture most or all of the requirements of space launch plus those for permanent human habitation in space. Therefore, the initial investments must be made in the development of the initial capacity to provide these necessities: materials, energy, transportation, communication, life support, radiation protection, self-replication, and population.

Once the needs of the permanent settlements have been met, any additional production capacity could be used to either extend that initial infrastructure (a concept commonly called "bootstrapping") or traded back to the Earth as a payment for the initial investment or in exchange for goods more easily manufactured on the Earth.

Although some items of the infrastructure requirements above can already be easily produced on the Earth and would therefore not be very valuable as trade items, like oxygen, water, base metal ores, silicates, etc., other high value items are more abundant, more easily produced, of higher quality, or can only be produced in space. These would provide a very high return on the initial investment in space infrastructure over the long-term.

Some of these high trade value goods include precious metals, gem stones, power, solar cells, ball bearings, semi-conductors, and pharmaceuticals.

In the 2,900 km of Eros, there is more aluminium, gold, silver, zinc and other base and precious metals than have ever been excavated in history or indeed, could ever be excavated from the upper layers of the Earth's crust. The smallest Earth-crossing asteroid 3554 Amun is a mile-wide (2 km) lump of iron, nickel, cobalt, platinum, and other metals; it contains 30 times as much metal as humans have mined throughout history, although it is only the smallest of dozens of known metallic asteroids and worth perhaps US $20 trillion if mined slowly to meet demand at 2001 market prices.[22]

The main impediments to commercial exploitation of these resources are the very high cost of initial investment, the very long period required for the expected return on those investments, which is estimated to be 50 years or more by some, and because it has never been done before, which imparts a high-risk nature to the investment.

[22] *http://en.wikipedia.org/wiki/Space_colonization*

The nationalism factor

Space proponents counter the above argument by pointing out that humanity as a whole has been exploring and expanding into new territory since long before Europe's colonial period, going back into prehistory; that seeing the Earth as a single, discrete object instils a powerful sense of unity, connectedness of the human environment, and of the immateriality of political borders; and that in practice, international collaboration in space has shown its value as a unifying and cooperative endeavour.

4.20 Escaping Extinction – Creation of Backup Colonies

Space colonies do not currently exist. It can be said, however, that humans have had a continuous space presence since 2000 due to the International Space Station. There is concern that the human species may lose its organized societies or its technological knowledge, use up required resources or even become extinct before it colonizes space.
Space and survival is the relationship between outer space and the long-term survival of the human species and civilization. It is based on the observation that space colonization and space science could prevent many human extinction scenarios. A related observation is the limited time and resources thought by some to be available for the colonization of space.

Extinction can be prevented by improving the physical barrier or increasing the mean distance between people and the potential extinction event. For example, people may survive imminent explosions by being in a bunker or evacuating. Pandemics are controlled by putting exposed people in quarantine and moving healthy people away. In the long history of animal life on Earth only lineages that diversify survive into the deep future. Our lineage, genus Homo, has reduced from several species co-existing on Earth to just one – all but our own going extinct since the start of the last Ice age. This would be a danger sign for any other large mammal genus. Space colonization, particularly of other star systems, would allow our genus to diversify and adapt to potentially new habitats.

Barrier

Life support systems that enable people to live in space may also allow them to survive hazardous events. For example, an infectious disease or biological weapon that transmits through the air could not infect a person in a closed life support system. An internal supply of air and a physical barrier exists between the person and the environment.

Location and distance

Expanding the living area of the human species increases the mean distance between humans and any hazardous event. People closest to the event are most likely to be killed or injured; people furthest from the event are most likely to survive.

Multiple locations

Increasing the number of places where humans live also helps to prevent extinction. For example, if a massive impact event occurred on Earth without any warning, the human species could possibly become extinct; its art, culture and technology would be lost. However, if humans had previously colonized locations outside the

Earth, opportunities for the survival and recovery of the species would be greater.

Objections to backup colonies

Creating a backup colony in space is a very costly method, and it is likely that other ways of creating an independent colony are more cost efficient. While extinctions occur on the order of tens of millions of years, major damage to the structure of the Earth itself is likely on the order of billions of years. As a result, an independent surface colony, or an oceanic or sub-terrestrial colony may be a cheaper way to obtain the same result.

The argument for diversified human populations also depends on these populations being "human". As speciation in the Homo genus occurs on the order of 100,000 to a million years, an independent colony may not be "human" after a short time on a geological scale.
Far more likely, an independent colony may revolt and pursue its independent self interest. In terrestrial civilizations, this frequently occurs on the order of 10 to 100 years. Even a loyal colony may decide that it is against its economic or political interests to aid a troubled Earth, or to re-colonize Earth.

The survivability and sustainability of a colony would likely be significantly less than the survivability and sustainability of the Earth population. Creating colonies that can reliably withstand the rigours of space and unpredictable extra-terrestrial environments for thousands of years may not be physically possible. Creating colonies that can not only survive, but grow to the scale that they can support programs to create their own new colonies is a far more difficult task.

4.21 Solar Wind

The solar wind is a stream of charged particles – plasma – ejected from the upper atmosphere of the sun. It consists mostly of electrons and protons with energies of about 1 keV. These particles are able to escape the sun's gravity, in part because of the high temperature of the corona, but also because of high kinetic energy that particles gain through a process that is not well-understood at this time.

The solar wind creates the Heliosphere, a vast bubble in the interstellar medium surrounding the solar system. Other phenomena include geomagnetic storms that can knock out power grids on Earth, the aurorae such as the Northern Lights, and the plasma tails of comets that always point away from the sun.

As the solar wind approaches a planet that has a well-developed magnetic field (such as the Earth, Jupiter and Saturn), the particles are drawn away by the Lorentz force. This region, known as the magnetosphere, causes the particles to travel around the planet rather than bombarding the atmosphere or surface. The Earth itself is largely protected from the solar wind by its magnetic field, which deflects most of the charged particles.

Planets with a weak or non-existent magnetosphere are subject to atmospheric stripping by the solar wind. Venus, the nearest planet to Earth, has an atmosphere 100 times denser than our own. Modern space probes have discovered a comet-like tail that stretches back to the orbit of the Earth.

Mars is larger than Mercury and four times farther from the sun, and yet even here it is thought that the solar wind has stripped away up to a third of its original atmosphere, leaving a layer 100 times less dense than the Earth's. It is believed that the mechanism for this atmospheric stripping is gas being caught in bubbles of magnetic field, which are ripped off by solar winds.

Mercury, the nearest planet to the Sun, bears the full brunt of the solar wind, and its atmosphere is vestigial and transient, its surface bathed in radiation.

The Earth's Moon has no atmosphere or intrinsic magnetic field, and consequently its surface is bombarded with the full solar wind. The Project Apollo missions deployed passive aluminium collectors in an attempt to sample the solar wind, and lunar soil returned for study confirmed that the lunar regolith is enriched in atomic nuclei deposited from the solar wind. There has been speculation that these elements may prove to be useful resources for future lunar colonies.

4.22 Space Marketing

Companies eager to expand their market share are turning their attention to the sky and beyond. In the age of globalization, space is the final frontier for advertisers. Few backdrops on Earth can match the limitless possibilities of space. Anything that is flown in space has increased value. This is obvious from the collectors' market and the fact that museums collect objects that are flown in space. So it could be a real marketing bonanza for manufacturers to be able to send products in space. To the advertisers, it is the ultimate in high-profile product placement; to the astronauts, it is a little bit of home 220 miles (355 kilometres) up. However, while NASA may see it as an unnecessary distraction prohibited by federal law, the people at Rosaviakosmos (the Russian Aviation and Space Agency), see it as a new and encouraging source of much needed funding.

The tradition of flying commercial products to space is not new. In fact, it can be traced to the early days of the manned space programs. Given below is a brief history of space marketing in the making:

Minolta Hi-Matic camera (1962):

NASA did not originally include an onboard camera, fearing it would be too much of a distraction for the astronaut. But eventually they submitted to allowing John Glenn to carry a camera on board his Friendship 7 orbital flight. The space agency struggled to develop a one-handed solution to snapping photographs and advancing the film. Meanwhile, Glenn stopped by a drug store on his way back from a haircut, where he found the self-winding Minolta. As he explained to Popular Science magazine in 1998, he bought it on the spot.

Omega Speedmaster watch (1965):

Though it was not known to Omega for nearly a year, NASA selected the Speedmaster for use by their astronauts. But before that the watch had to undergo multiple tests that were designed to simulate the rigours of spaceflight. Since then, the watch has had the distinction of being the only model worn on the Moon and is now used by both American astronauts and Russian cosmonauts living aboard the International Space Station. To recognize the achievement, Omega renamed the watch the Speedmaster Professional.

Fisher Space Pen (1968):

Never has there been a better example of being in the right place at the right time than the Fisher Space Pen. Invented in 1966 as the better ballpoint pen refill, Fishers cartridge pressurized by nitrogen did not require gravity to feed ink to the paper. As such, the Apollo 7 crew became the first astronauts to rely on pens, the AG-7 Space Pen to be exact, for taking notes while in orbit. Since then, both U.S. and Russian flights have carried the versatile writing tool. Meanwhile on the ground, Fisher has taken advantage of its place in space, ultimately arranging to have the pens hawked from space during a live hook-up with Mir on the home shopping network QVC.

Golf balls (1971):

Recognizing the power of an astronaut's endorsement, Apollo 14 Moonwalker Alan Shepard agreed to never identify the manufacturer of the two golf balls he hit off the lunar surface. For years following his return, Shepard was reportedly approached to endorse golf balls and related products. He never did.

Coca-Cola and Pepsi soft drinks (1985):

Though NASA labelled it the Carbonated Beverage Dispenser Evaluation (CBDE), it can be considered as the taste test to end all taste tests. Soft drink makers Coca-Cola and Pepsi seized the opportunity when NASA approved an experiment to test the viability of carbonated drinks in space. Despite strict rules preventing the rival cola makers from exploiting the experiment, the first unofficial taste test in space became a marketing coup for both companies. The "experiment" included specially designed soda "cans", produced by both Pepsi and Coca-Cola. Though the crew classified the experiment as a failure citing the zero-G environment and the lack of refrigeration, Coca Cola flew twice again using an improved dispenser and pressurized glasses, ultimately spending more than $750,000 in the process. Pepsi, on the other hand, later filmed a commercial aboard the Mir space station in 1996 for a reported $5 million. They both were really not interested that much in providing soda to the astronauts. They were really interested in providing soda to the masses here on Earth. And even with NASA strictures about advertising, each of them was now able to claim having been first in space.

Slinky toy (1985):

This "favourite of boys and girls" was flown aboard the space shuttle to demonstrate how various toys would react to microgravity. The aptly named Toys in Space experiment encouraged the astronauts to play while they were filmed to record the reactions. The resulting video was distributed to teachers as a means to teach children about the basic physics of spaceflight.

Pizza Hut:

In 2001, the marketing of space took a giant leap forward when Pizza Hut flew with the Russian Space Agency. For about a million dollars, the fast food company gained worldwide publicity and bragging rights as the first to deliver hot pizza in space. A Pizza Hut logo appeared on the side of the Proton rocket that launched the Zvezda service module; part of Russia's commercialization of its cash-strapped space program.

Radio Shack:

Electronic retailer Radio Shack followed soon after and filmed a commercial aboard the International Space Station featuring a Russian cosmonaut opening a Father's Day present.

NASA has been reluctant to take part; its rule has always been, 'no product endorsements, generic entities only, and no commercial exploitation of flight on the shuttle.' But it is possible that this could change in the future under continuing pressure. Marketers say that advertising could help fund scientific research if NASA relaxed its stance on product endorsements. NASA says it is working to conduct an agency wide evaluation for a commercialization strategy in space.

4.23 Star Wars

Space weapons are weapons used in space warfare. They include weapons that can attack space systems in orbit (i.e. anti-satellite weapons), attack targets on the earth from space or disable missiles traveling through space. In the course of the militarization of space, such weapons were developed mainly by the contesting superpowers during the Cold War, and some remain under development today.

In recent times satellites have been hacked by militant organizations to broadcast propaganda and to pilfer classified information from military communication networks. Satellites in low earth orbit have been destroyed by ballistic missiles launched from earth. Russia, the

United States and China have demonstrated the ability to eliminate satellites. In 2007 the Chinese military shot down an aging weather satellite, followed by the US Navy shooting down a defunct spy satellite in February 2008.

Orbital weaponry

Orbital weaponry is any weapon that is in orbit around a large body such as a planet or moon. As of 2009, there are no known operative orbital weapons systems, but several were designed by the United States and the Soviet Union during the Cold War.

Development of orbital weaponry was largely halted after the entry into force of the Outer Space Treaty and the SALT II treaty. These agreements prohibit weapons of mass destruction from being placed in space. As other weapons exist, notably those using kinetic bombardment, which would not violate these treaties, some private groups and government officials have proposed a Space Preservation Treaty which would ban the placement of any weaponry in outer space.

Orbital bombardment

Orbital bombardment is the act of attacking targets on a planet, moon or other such object from orbit around the object, rather than from an aircraft, or a platform beyond orbit. It is most often encountered in fiction, but has been proposed as a means of attack for several real-world weapons systems concepts, including kinetic bombardment and as a nuclear delivery system.

During the Cold War, the Soviet Union deployed a Fractional Orbital Bombardment System from 1968-1983. Using this system, a nuclear warhead could be placed in low Earth orbit, and later de-orbited to hit any location on the Earth's surface. While the Soviet Union deployed a working version of the system, they were forbidden by the Outer Space Treaty to place live warheads in space. The Fractional Orbital Bombardment System was phased out in January 1983 in compliance with the SALT II treaty of 1979, which, among other things, prohibited the deployment of systems capable of placing weapons of mass destruction in such a partial orbit.

Orbital bombardment systems with conventional warheads are permitted under the terms of SALT II. Most such proposed systems rely on long rods dropped from orbit and depend on kinetic energy, rather than explosives, for their destructive power.