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« THE FIFTH SEASON »

THE SPACE 'BINGO' SURPRISES: VERY PROFITABLE AND NOT OBVIOUS GIFTS OF SPACE

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ABSTRACT

Large public opinion usually thinks about space as a very difficult, dangerous and unsafe environment. Recent and less recent catastrophes reminded to us how Earth can be unsafe, causing the death of thousands Terrestrials in few minutes. It is very urgent to bring to the public attention some benefits of space, and points where space is easier, safer and more convenient than Earth, at least: a) Easy transport at zero gravity zero attrition. b) Light space structures vs. heavy earthling ones. c) Earth is pregnant, not ill! d) Boundless energy. e) Halved the possibilities of extinction of human kind. f) An artificial orbiting house can move, if something is coming to hit it. g) Using the fall into gravitational wells to accumulate energy. h) Being out of the gravitational well is a higher degree of freedom. i) Growing economy vs. stagnation and decay. The paper outlines and proposes a proper publishing programme, to collect all the space eases and conveniences, find out proper experts to speak about each one of them, develop TV programs and other media issues.

THE FIFTH SEASON

End of the Terrestrial Civilization?

The first years of the new millennium seems not to be under a good start. Our energetic resources are dramatically scarce[1], food resources and cultivable ground are shortening too, backwarded conflicts threaten our daily life, global economy is stagnant, lacking of strong industrial development lines[2]. Environmental problems – be they caused or not by human growth – threaten our health and survival. Two Asian giants, China and India, started their industrial development, and it is likely that the resources of this planet will not be enough to allow the completion of it. Such a scenario lets envisage other conflicts at the horizon, even worse than the current one, between some western countries and the jadist-qaedist terrorists.

Decadent cultural vectors unfortunately dominate the cultural scene; the industrial decline and the stop of the development are generally accepted, when not advocated, by particular recessive philosophies. This paper doesn't aim to analyze the reasons of such a status of things, that I discussed in several other writings (see some samples in [3][4][5]).

In general terms, we can say that our growth, as a *sentient species*, is very near to its natural limit, in the closed environment of this planet. And the awareness of the environmental and resources problems is, at the same time, the measure and

the agent of such a process. At this point, if we weren't a technological species (if we weren't an *intelligent species*), our situation would be without hopes. Homo sapiens had a springtime season, since pre-history to Neolithic begin; a summer, from Neolithic revolution to the advent of written cultures; an autumn, with the harvest of our cultural progresses, up to our present days. And we would be now entering the winter, end of our civilization, since we would not have other space nor resources to develop further.

But the above is an impossible paradox: if we weren't an intelligent technologic species we would have had another history, not so different from the one of sharks, or other predators at the top of the food chain, or maybe even not at the top (humans' only weapon was their intelligence, compared to other predators).

Out of hypothesis and paradoxes, this is what we are: an intelligent technologic species. And, btw, we hold a space technology, though at initial stage. So we have an alternative: we can have a *fifth season*, after winter.

And such a fifth season can only be out of our birth planet. The fifth season can only take place in the extraterrestrial space.

Space: option or imperative?

In the large public opinion, if the awareness of the possible end is very diffused, not so we can say about the awareness of the real alternatives.

The human expansion in the extraterrestrial space is rarely addressed in its full potential. More often our *prudent and reasonable* leaders prefer to talk about research, exploration, and more often they turn their look on Earth, rather than to the sky.

By the large public opinion, space is mainly seen, in the best case, as an option. Leaving apart the supporters of the humans' decline (I am not so much interested to discuss with such people), the awareness of space ranges more or less as follows:

- a waste of public money;
- a dangerous environment, where we should avoid to go (better send robots, if really needed);
- an interesting subject for entertainment;
- a tool to enlarge our scientific knowledge;
- one of the options[6] for development, to be attentively compared with other scientific developments (nano-tech, bio-tech, global telecommunications, etc...).

I don't have doubts that some promising scientific developments can do many, for the continuation of our civilization. But, any scientific development that allow us to grow up a little bit further in this closed environment, will only delay our end of some tens of years. So *they are not true alternatives*. Earthling science can only help us to survive a little more during winter: it will not give us a fifth season!

That's why – and I think useful to restate it here – I don't think that the space perspective was an *option*, for humans. It is an imperative, as Krafft A. Ehrlicke so farsightedly pointed out more than 30 years ago[7]!

The fifth season is in space

It is only in the extraterrestrial space that humans can escape the many physical limits of this planet: gravity, attrition, time constrains, season cycles, resources finiteness, territory, environmental constrains. Settling out of the terrestrial atmosphere and gravitational well we will achieve a very greater degree of freedom.

From a conservative point of view, one could object that we are not ready for this level of freedom, not scientifically nor culturally. Since we didn't yet understood completely how, and at what extent, gravity and seasons influenced our growth, our physiology and our history, not to speak about the influence on agriculture and other forms of natural lives that we need to support our biological life. Of course, if we were in a safe situation, and we had time enough to consider all alternatives, to trade-off different solutions, and to better study the Earth's biology, then we could maybe lend ears to such positions. But we aren't in a safe situation, not at all: our growth in a closed system reached a critical point, and, waiting some other tens of years, we could loose the positive momentum (due to quick economic decay and worsening of the conflicts), and waste the unique opportunity of our civilization to *get the fifth season*. Furthermore, should we accept any further delay in opening the high frontier (we already are 30 years late), I am sure that priority would be given to any other thing, but to better study Earth's biology.

Therefore we *shall* go, and we shall have to learn managing the very huge freedom of leaving

and working in space, and the – for some aspect strange – gifts of the fifth season: boundless energy, possibility to model the duration of the day, possibility to decide weather conditions, artificial season conditions, artificial gravity and no gravity, just to mention the most evident ones. Our planet gravity, days, seasons, air, determined the fact that we weight from 50 to 90 kg, we are 150 to 200 cm tall, we can breath and speak and run, and swim, and make love, and work, and all the other things we make. If we think to all that, we have surely reasons to be frightened by *the absence of such constrains*, that we will experiment, and that astronauts already experimented, leaving on MIR and ISS. And to the presence of other constrains: closed small environments, black empty space just outside the window. So what? Pioneers experimented new and strange conditions along our whole history! It will simply be a new challenge (the greatest never faced... glom...). How the beauty canon will change, for our Lunar, Martian and Lagrange nephews, will be a problem of many generations in the future. It is very much more interesting to imagine how *their thoughts will change*, leaving in extraterrestrial environments, and the cultural achievements, in a true boundless development space. A wonderful future, very very much better than the slave and barbaric future, practically sure, if we will remain a terrestrial-only society, bounded by this planet' limits.

Awareness

Now, this paper is not aimed to deny *the many difficulties* of living and working in space, nor the author wants to minimize the very serious effort that's to be done, to overcome them. But so many pages were written about difficulties, while very few were written about the many *easies and space gifts*! If we re-read the works written by some scientists/philosophers during years '60s and '70s of the past century (O'Neill, Ehrlicke, and others), and considering that Man stepped on our moon in 1969, we are 30 years late, in the Solar System colonization program. Maybe such a situation is partially due to the too little literature about the space gifts. It means that (i) the pro-space movement was not able to communicate enough to the society, and maybe it didn't have ideas clear enough; (ii) the political leaderships didn't understand the urgency of the situation; (iii) general conditions were not yet enough evident, and the development supporters could cuddle themselves in several illusions (telecommunications, *sustainable* development, etc...). Nowadays we can observe that condition (iii) is radically changed, and the space for illusions is more and more narrowing. But political and social processes are characterized by a very high degree of inertia, and we well know the dullness of the politicians.

Therefore it is very urgent to intensify the discussion inside the pro-space movement, all the organizations, the agencies, the scientists, the well-willing people, in order to clarify the general situation in which we are moving, to simplify and generalize some goals, to better define *items for a true and effective space promotion world wide campaign*.

The above agenda seems obvious, but it is not. Reading any economic/technological development forecast, it is disheartening to see that space technologies are considered marginal, in the best

cases. This means that the "real society" economists are very little affected by space. There are many concepts that are not evident until one makes a personal experience of them. We see so many things on TV, Internet and other media, that sometime some true gold objects can pass in front of us, together with thousands of "dorè" pieces of iron, and we don't pay attention to them. In order to focus our attention, the gold shall be separated from iron, and properly presented, in the due cultural dimension.

The personal experiences of the people who were stroked by an intuition and, from one instant to the subsequent one, had an enlightening vision, are particularly precious, because these people can communicate their vision with a great capacity to make it evident for other people too.

The more entrepreneurs will become aware of the great convenience and easiness of space, the more probabilities will exist, that the high frontier will be open indeed.

THE SPACE SEASON FRUITS

Many seeds of the space season fruits were already sown in the writings of our beloved maestros, 30 or 40 years ago. Other seeds are instead hidden in the society: who knows how many intuitions never come to light, and remain lost for humanity? I would like to collect as much as possible of such visions, and help the visionaries to communicate them to the other people...

Hereafter I will report the intuitions, which struck my mind, and, at least in a couple of cases, how it happened.

Cheap transportation

Many scientific papers discuss the convenience of the space transportation, giving figures and forecasts. But my striking vision didn't come while reading a paper.

In December 1997, a Proton rocket had a malfunction, and its payload, Asiasat 3 – built by Hughes to supply TV emissions and telecommunications to most of Asia –, was inserted in a strongly elliptical orbit, completely useless for its mission[8]. It was originally foreseen to reach a geo-stationary orbit, at 36.000 kms from Earth. The small onboard engine, designed to perform small asset corrections, had not enough fuel to correct the course to the right orbit. The insurance companies declared the satellite unusable, but the Hughes engineers didn't give up, and conceived a rescue plan never tried before: though the rockets of the satellite weren't enough to taking it on a good orbit, were anyway enough, paradoxically, to send it behind the Moon, 400.000 kms faraway! The Moon gravity attracted the satellite and then re-sent it to Earth, but this time in a different orbit, useful for commercial use. Such technique, called "gravity assist", was several times used for the interplanetary NASA's probes. Apollo 13 itself was saved by the lunar gravity.

I was strongly shocked by such a news, and started to look for similitudes: what would you think if someone, starting from Italy by a small raft, equipped by a 6 cv engine, made a trip to New York and return, all with few litres of gasoline??! And surely the proportion is still wrong: in

the case of our satellite, we are speaking about 800.000 km, vs. few km, that its small engine was designed to cover, during the whole operative life of the satellite, to correct the orbiting asset. Of course the whole Moon journey took more than six months. But the potentialities are enormous. Just think about sending non-perishable goods from Moon to Earth or everywhere else in the Solar System: you can transfer a whole cargo, using a motorbike engine! The profits, for a *mercantile space transport enterprise*, are simply incalculable. And the benefits, for a space economy, in terms of development potentiality, are incalculable as well.

Such a fantastic *easiness of space* is of course due to two conditions: absence of gravity and absence of attrition. Two things that, here, on the bottom of the gravitational well, in our atmosphere, make each kg-km cost a lot of money, in fuel and wear and tear of the machines. As Gerard O'Neill wrote more than 30 years ago, the American transport system spends 25% of the total energy to fight gravity and air attrition, that means a waste of 2,5 oil tons for each citizen[9]. An upgraded calculation should be made, to know what is the waste of energy for transportation on the whole planet. Then invite many transport entrepreneurs, in a big convention, to assess the convenience of the space transportation. And first of all they should be entertained by a well-illustrated story of Asiasat 3!

Structural lightness of space engineering

A couple of years ago I visited my friend, Dr. Marco C. Bernasconi, at his home in Zurigo. Marco is an expert (one of the few, in Europe) of *inflatable and chemically rigidizable technologies* for space. In that period we were working together, so I had at my shoulder more than one year of discussions about inflatables, gossamer structures, etc... But I was absolutely not prepared to what I saw, and touched, on the Marco's desk, in his studio. Therefore it was a kind of *shocking vision*, for me. During his 20 years work on inflatables at Oerlikon Contraves, Dr. Bernasconi designed and built tens of ground test prototypes, and a piece of one of those works was making nice show of itself on a corner of his desk. It was a kind of "T" connection, a tubular section of a very much bigger structure. (see Fig. 1). The object's dimensions could be 60 x 60 cm., and the diameter of the tubes could be 20 cm. Being myself a very curious person, I was standing in front of such thing, trying to understand what the hell it could be. My friend was observing me with his characteristic ironic half smile. The appearance of the object was a complete nonsense, especially for the thickness of the material, that could be no thicker than 0,1 mm., a sheet of paper, maybe less. At the end I resigned, and asked him: "Marco, tell me this is not what I think it is..?" "Of course it is" said him, without stopping to scratch the neck of his cat, comfortably sitting in its basket, on the other corner of the desk.

The thing was a section of a complex inflatable structure, the ISRS Solar Shield for FIRST[10]. I'm perfectly aware of my bad impression, if I was a scientist. But I not a scientist! (I'm only a process control systems designer :-).

Out of kidding, I think the potential shock-vision of closely observing an inflatable structure, and tasting by fingers its thickness is as much im-

portant as the previous case, of the space transportation.

Why was I shocked? Because I am used to see earthling structures. An earthling structure of the dimension we can see in Fig. 1 shall be a very solid structure, even only to sustain itself. If we think to other kinds of structures, e.g. solar arrays and transmitting-receiving antennas having tens meter diameter[11] like the one in Fig. 2, we suddenly imagine very heavy structures and pylons. On Earth, our engineering has to fight with gravity, winds, and with many kinds of vibrations, which occur on our planet' surface.



Fig. 1. The ESA "FIRST" Solar Shield

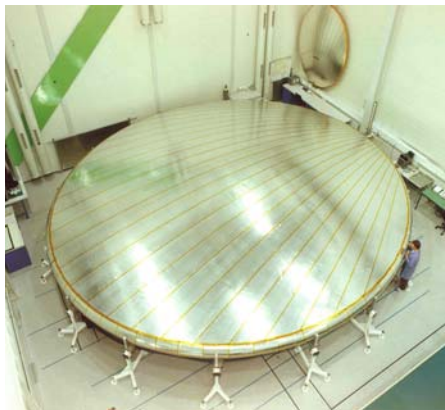


Fig. 2. Inflatable Space Rigidized Antenna Reflector Structure

Thus, the first thought, when I saw and touched an inflatable structure, was a smile: "It can't work, tell me that you are not deploying in space this garlic-skin!". If you look at the pictures, representing the inflated structures in their test chambers, you can't realize *how light and inconsistent* they are. Very simple: they are not made for this planet. They are pieces of extraterrestrial technology. I would wish that many people could feel the fascination of touching a piece of extraterrestrial technology.

Scientists mostly do not understand the wonder of what they're doing. For them it is perfectly normal and obvious. So it was the answer of my friend: "Why the hell do you want heavy and thick

structures, where there's no gravity and no wind?". He was surprised of my surprise. So are scientists. Thus our society – missing curious scientific journalists, available to not hide their surprise – will keep on lacking some very profitable and progressive wonders.

Coming to a financial reasoning, it is easy to imagine (though not so easy to calculate) the convenience of the space engineering, vs. the earthling one. In its already quoted book[9], Gerard O'Neill makes a couple of considerations. Speaking about energy, a simple reflector of a football field size, in zero gravity will have a mass not greater than a car. In order to produce the same amount of energy, an earthling power plant should burn one million oil barrels for thirty years. The space reflector will produce the same energy at zero cost, until when the Sun will shine.

From the maintenance and wear and tear points of view, a space industrial plant, at zero gravity, will cost a small fraction of its earthling sister. In fact, though turbines, generators and machineries will have thousand tons masses, they will weight zero in absence of gravity, so they will work with bearings or in air, without attrition, having so a practically endless operative life. Not to speak about the maintenance operations, very easy in absence of gravity. According to O'Neill, the space industry can be built in volume, rather than on plain surfaces, thus all the user machines will be very closer to the central power plant, and the distribution structures will be very shorter.

The solution of the energy problem forever

The Sun boundless energy, at nearly no cost is waiting there for us, just outside of our cosmic home. Calculations on the convenience of the solar space power were made many years ago[12]. A panel in orbit is always oriented to the Sun (the space sunflower concept) and receives (except at eclipse) 1400 W/m², 24h/day, 365 days/year. The yield is incomparably superior to the photovoltaic on earth, where we have to make counts with night time, bad weather, different insulation areas, etc... Furthermore, we can deploy very big surfaces of panels, without any problem, while on earth we had many problems with the ground, that should be covered by black panels for very large extensions. From the environmental point of view, SPS would move the most part of the thermal burden out of the planet' atmosphere.

Recent studies[13] show that very profitable synergies are possible between space solar power plants and passenger space transportation. The development of the space tourism market will lower the Earth-to-orbit cost. A low ETO cost will lower the cost of realization of space power plants, at least in the first phase. Later the main materials for space power plants will be produced at lower cost on the Moon or asteroids. The possibility to supply energy from space to *space clients* (hotels and orbiting industrial platforms) will lower the costs of such facilities, and this will further enlarge the markets. The more we will increase our activities outside of the gravitational well, the more the space economy will take off, and we will also become able to *exploit the gravitational well*, after having invested to escape it.

The products of the gravitational well

To look into a well from the top is very different than watching up from the bottom. Standing on the top of the well we will own very precious *quantum's of potential energy*. The possibilities to exploit the Earth – Orbit momentum, or the momentum between two different orbiting levels, only rely on proper technologies. Technologies will have birth when people will be sitting there, and will concretely see the possibilities.

The first opportunity is the very huge energy that is currently wasted – and with high danger for the safety of the astronauts – when the spacecrafts re-enter the atmosphere. Could those 25 minutes of hell be used to charge an electric accumulator? Why not? If we were able to think about the nose of the shuttle as a plasma-breathing engine, with a grid in front, and a powerful heat exchanger just after the grid, maybe it could be possible! Each descent in the gravitational well would than repay in part the cost of the launch, and would decrease the danger for astronauts.

The asteroids belt Cornucopia

Just after the Mars orbit, and well before the Jupiter orbit, centered at about 2.7 of the Sun-Earth distance, the asteroid belt[14] is a nearly endless reserve of raw materials. It was estimated that the total mass of the Belt may total less than 1/1000th of the Earth' mass. But, as O'Neill wrote in his already mentioned book of 1976[9], mining Earth requires hard drilling, since the most of the Earth' materials are inside the planetary body. Asteroids are a very high number of small objects, very very easy to mine. O'Neill calculated that, if we dogged down to 800 m. *the whole Earth surface*, and we removed the 10% of the total volume of the spherical layer, we had got only the 1% of the materials contained in the three bigger asteroids!

Most asteroids may be composed of three materials: mostly silicates, metals (iron and nickel), while the rest is a mix of those materials and carbon-rich substances. All what we need, in order to build habitats, the machinery needed to sustain life and artificial ecosystems, and industrial plants for economic activities.

Signs of a golden age

All the light we're able to enjoy, and something more

The visionary genius of Gerard O'Neill drafted huge orbiting space colonies, with many km. extension, mainly located at the L5 Lagrange Points. Even thinking, initially, to smaller structures, like hotels and ISS-size industrial plants, any of such structures will benefit of boundless and very abundant sun light and energy. People don't usually really focus what this will mean, for the pioneers who will leave and work there, but also for terrestrial inhabitants. Do you remember that 300W halogen spot that you brought home, in a rush of optimism? How many times did your wife (or husband) allow you to switch it on? Maybe, sometimes, when you have guests for dinner... thinking that it is part of the dinner budget. But what a warm and beautiful

atmosphere, when it's on! Every metal surface is shining, and golden details sustain your positive thinking very very much!

Now, think about having ten or twenty of those things in your home, and that you can switch them on all together, for all the time you like... Think that you can allow yourself to play with light, creating different environments, using powerful lights and different colors, getting the effects you like more, from soft shades to violent contrasts, silk and gold, flames and fluid blue waters. Got the idea? Ok, we're on a space habitat, where the sunlight comes directly to us from panels, by thousands of optical fibers, or under the form of electric power, powering our lamps. Of course the concept applies to all electric and electronic equipments, for music, for domestic comfort, for entertainment, etc...

Unless we are billionaires (unfortunately very few of us), we never experimented, on Earth, a situation in which we can use all the energy we like. In space we will can.

The space green revolution

The boundless availability of sunlight, power and heat will be used for intensive cultivation. What is the production potential of an environment whit boundless energy and absence of gravity? Add to the picture the complete absence of parasites, and the result will surely be greater than the result of the earthling "green revolution", and all without using pesticides or other dangerous chemical products, that were the main factors of the green revolution. "*Through the mechanisms of irrigation,*" writes Gunter Pauli[15] "*of massive water use, through seed selection, through fertilizers, herbicides and pesticides, we were able to achieve seven times more output of rice per acre than we had forty years ago. This is not a bad result! Yet it's not sustainable. It is not possible to continue with such use of water. We're depleting the aquifers.*" Pauli advocates a second green revolution, on Earth, by means of a very sharp re-engineering of the food production processes, implementing optimized synergies to fully eliminate wastes. I like very much Gunter Pauli and his research, because he is a very honest scientist-economist, aimed to an intelligent use of technology, to implement a sustainable economy (and not to a bleak give up, accepting the decay). Maybe he could succeed, improving the earthling sustainability. But for how much time? Ten, fifty years? Then he too shall bend to a no-growth future. Not so the *space green revolution*.

The space agriculture will take raw materials from the Moon and the asteroids, will use boundless space to deploy cultivated fields, and boundless energy to grow up beautiful and abundant good food. The *space farms* will supply food to space clients and to Earth ones. Imagine tens of big cargos, entering the Earth gravitational well each day, charging themselves during the 25 hot minutes, and reaching the ground with a charge of food and energy...

Space farming will sustain the growth of hundreds billions humans, while Earth will become a beautiful ecological garden...

Personal wellness and arts

The great majority of us work a full year, and, except few lucky ones, living in a tropical paradise, we don't benefit enough of the Sun light and energy. When we stand up, in the morning, the mirror gives us back the result: our skin is pale, and our flesh is... *out of tune*. What does it happen, contrarily, in those two or three weeks when we take some holidays, at seaside or mountains? A kind of miracle: even if we don't loose weight, the mirror begins to be very more civil, showing us the face we had years before. That miracle is made by the concurrence of five conditions: (i) Sun light, (ii) rest (iii) having fun (iv) eating well (v) physical activity (swimming, walking, etc...). After some days of holiday, our humor is very high, we feel very optimist about the solution of our problems, life is smiling to us, and all the relations with our relatives and friends improve accordingly. If you are a person used to take note about the changes of your feelings and moods, you can't avoid asking yourself: "why can't I live the whole year like these few days?"

On space habitats, the Sun light is continuously 100% available, without interruptions nor reductions, with its full healthy power. The only problem will be – since we will not have the atmosphere protective shield – to find engineering solutions to filter the hard Sunlight radiations, allowing only the good ones to reach us. However we will have the same problem also on Earth, if the ozone layer will keep on reducing.

The space habitat can validly contribute also to point (ii) of the list. To sleep in zero gravity – as reported by many astronauts – is the best way to rest they ever experimented. When you lay in an earthling bed you always have some problem (where to put your arms, how to stay on your left or right shoulder, etc...): at zero gravity you can completely forget your body, and sleep avoiding the problems of "positions". Of course, if you prefer, you can sleep in the artificial gravity area.

Point (iii) of the list – having fun – and point (iv) sport activities, will be very much enhanced, in the space habitats. To the traditional gravity sports, perfectly feasible in the artificial gravity zone, a zero gravity environment can add several very exciting new sports: flying in the air, diving in zero gravity pools, different games using one or more balls, races, and so on.

Zero and low gravity also offer to musicians and theatre artists an incomparable environment for experimentation and research!

Safety

Large public opinion usually thinks about space as a very difficult, dangerous and unsafe environment. Journalists and opinion makers do not contradict such a completely false metaphysics. Yet, recent and less recent catastrophes reminded to us how Earth can be unsafe, causing the death of thousands Terrestrials in few minutes[16][17].

Until when we will remain a Mono-Planet Civilization, we will be exposed to a very high number of dangers and potential extinction menaces, both natural and man-generated. As a not exhaustive list:

- asteroids and comets impacts
- environmental crisis

- resources shortage
- epidemics
- natural catastrophes (earthquakes, tsunamis, floods, etc...)
- very hot and very cold weather
- nuclear wars
- pollution

A rational thought should conclude that this planet is a very unsafe place for Humankind, if we will not quickly get some alternative places.

This choice would not mean to abandon our mother planet, of course. Contrarily, settling outside we will have better chances to take care of it.

Settling outside our mother planet, on artificial platforms or other celestial bodies, will grant us the best gift in absolute: halving the possibilities of extinction!

A second source

Many people, at least in the post-industrial world, had to manage computers, hardware, software and accessories. When they buy a piece of software or hardware they check attentively the existence of a second source, in order to be reasonably sure to have maintenance and spare parts for a good number of years. But the same people seem not to care at all the need to have a "second source" for their (and my) cosmic home!

Nevertheless, our safety – as a species – would decisively increase if we had at least a second source. This is *the main reason* for human space flight: settling on another celestial body we will half the possibilities of extinction of human kind[18].

Since nature didn't provide a second Earth-like planet, at our current range (Solar System), we will have to build artificial environments outside. But there are no major obstacles to this, except our nearsightedness and meanness!

Raw materials are plentiful, so water and energy, as we saw at the previous points, very cheaper than here on Earth, once we will be out of the gravitational well.

Defense from cosmic impacts

As documented by several archaeological proofs, several asteroids and/or comets stroked our planet, during its life of 4 billion years. "There are now more than 150 ring like structures on the Earth identified as definite impact craters. However, most of them are not obviously craters." Such data are reported on the Spaceguard web site[19]. On the same page, we find an interesting table of the relative probabilities of a citizen of the USA to die from a variety of causes: the possibility to die by a killer asteroid is 1/25.000, just after the probability to die in an aircraft accident (1/20.000), but before the one to die in a flood (1/30.000)!

After the very serious work made by Spaceguard UK, and by other asteroidal menace defence organizations, studies and simulations were made, in order to set up valid countermeasures, in case the rout of an asteroid or comet was colliding with Earth. Such studies not only explored the possibilities to divert and/or destroy the possible incoming objects, but also the

opportunities to catch them and use their raw materials for building the space infrastructure.

Well, an artificial space house can simply move, if something is pointing to hit it! This is a primary, very efficient way of defence, that our species experimented since the dawn of our history: the escape!

However, considering other ways, like destruction and/or capture, space settlements will be in a very much better position, to put in place any strategy, against an incoming cosmic object.

A boundless economic growth and freedom

The opening of the High Frontier, and the takeoff of a true Space Economy, will fully change our life, relaunching the global economy at a speed that we can hardly imagine.[20][21]

In July 2000, in the middle of the so-called *new economy* boom, I wrote these (unfortunately prophetic) words: "*I dare say that, missing the development of Astronautics and the colonization of the geo-lunar space, the terrestrial globalised Economy will know new heavy crises very soon. On the contrary, the start of a Space Economy, opening the world system, will assure a near-endless growth period.*"[22]

Up to now few economists dared make forecast calculations[23][24], about the possible numbers of the *very first steps* of the Space Economy: sub-orbital tourism and orbital tourism. Why economists are so shy?

Such a process will cause several evolutionary social processes, at least:

- softening of all the wars and conflicts;
- wish to cooperate and compete in the most gigantic adventure of all times;
- an extraordinary and long lasting thrust to arts and culture;
- progressive reduction of the poverty and underdevelopment;
- continuous birth of new market segments, with consequent continuous increase of wealthy opportunities for both the Terrestrials and the Spatials.

Why we need a Growing Economy

The virtues of a growing economy vs. the stagnation or decay are not stressed enough, since the discussion is encumbered by old wised, 20th century' ideological positions. The concept of growing economy shall be liberated from its old ideological ballast. The 20th century history shows that the collectivist regimes (both fascist and socialist), faced to bad economy (not only due to such a condition, of course), quickly involved into ferocious dictatorships. A fun joke says "*Capitalism is an unfair distribution of richness, while Communism was a fair distribution of misery*". In the aim of the revolutionaries, at least, since communism quickly ended to be an *unfair* distribution of misery!

A Growing Economy is a must in any ideological context. The concept is very easy: if *the pie is growing up*, there is a possibility (though not automatic) that a utopian society can realize, where everybody have the possibility to become rich, without pillaging other people. If the pie is

steady or, worse, decreasing, everyone will be afraid not to can feed his/her children. The fear is the mother of all conflicts, wars and barbarianism.

The *Space Fifth Season*, being an endless golden age, will assure a boundless environment for free development. A formidable perspective, for the relaunching and development of the global economy. A revolution that will outclass the first industrial revolution, and that will bring the world economy to an unprecedented development.

A new awareness is to be brought to the light: it will be the Space, that will provide the new industrial development lines, the new energy sources, and a horizon of open development. *It will be the Astronautics*, that will guarantee the economic and civil growth, in full liberty, for at least one millennium.

The incoming Space Economy

In [25] Patrick Collins draws a general picture of how the development of space industries, such as space tourism and all the related sectors can provide, *even if alone*, the whole development and growth scenario needed by the 21st century human society. He starts analyzing how, in 20th century, the declined industries (e.g. agriculture, steam-engines, mining, textiles, ...) were replaced by new industries, which re-employed the dismissed workers: car manufacturing and associated activities, electricity generation and distribution, entertainment, aircraft manufacturing and operation and associated activities, telecommunications, computers, tourism and an ever-growing range of leisure industries, including many sports activities. Collins notes that economic growth will not continue, in the 21st century, if the rich countries will not keep on creating new industries, suitable to employ people displaced from older industries, as they progressively automate and migrate to lower-cost countries. Discussing between Patrick and the author, we called such a process "the convective movement of technologies", among advanced and emerging countries.

Such a forecast, made by him in 2001, couldn't be more prophetic: the current western economy stagnation, faced to the Chinese and Indian growth, is there to demonstrate it.

"*Almost no-one in 1902*" writes Dr. Collins "*could even imagine, let alone predict, the rise of passenger air travel, nor a fortiori its growth to its current world-changing scale.*" Economic commentators today don't behave differently from their one century before colleagues: they predict growth in many areas of different technologies, but not in passenger space travel. However, "*The most significant industrial development of the 20th century was the development of passenger air travel from zero in 1900 to 1.5 billion passengers per year in 2000.*" Significant side effects include the growth of hotel and restaurant industries. In the same paper, Collins mentions market researches, pointing out that middle-aged and older Japanese people only wish to buy travel services. According to the study in [26] the number of space tourism customers could reach 700,000 per year, 17 years after starting the activity, at an average flight price of \$20,000 per passenger. When the number of passengers reaches one million per year, some years later, 10,000 people

will need to be housed in orbit, and several thousand staff will work in orbit. The hotel industry will probably become the largest employer in space, with a huge number of side industries, including construction, interior design, hotel management, catering, fashion, entertainment and sports. If the sector will grow to reach, as forecasts say, 5 million passengers in 2030, the annual growth rate will be 16%! What other market segment can assure such a two digits figure? *Speaking about the advanced countries*, of course.

In such a scenario, 40 million people would have visited space by 2030, and the cost to taxpayers to realize this scenario would be far less than the one they already paid for space agency activities. The economic value of the *space economy*, in expected profits, would be about \$1 trillion higher than if the space economy would not take-off. Several million people would be directly and indirectly employed in related activities.

The Moon Kindergarten

A giant test facility

Moon was presented as the best place where to set-up big telescopes and scientific laboratories. All this is true and of very great value. But another aspect – even more important, if we really want to start living and working outside Earth – was up to now neglected: due to its characteristics, the Moon is a giant test facility, for many things we can't test on Earth. Moon is a unique environment, at few hours navigation from Earth, which combines low gravity, absence of atmosphere, and a solid ground under feet[27]. Moon allows to build underground habitats, protected against space hard radiations, and to *experiment protection technologies against radiations*, using local facilities and workshops, to construct prototypes and testing environments.

Most of what it cannot be tested on Earth, due to the high cost of vacuum and low gravity simulation, on the Moon can be easy and cheaply tested. A recent ESA' ITT (to which the author participated, with other European partners) called to develop the conceptual design of a long-term mission test facility (FIPES)[28]. The facility' requirements include the simulation, in a wide building, of all the environmental conditions of Moon or Mars, during a 6 months lasting mission. But vacuum is not included: even half an hour of a good artificial vacuum is very expensive. 6 months is unaffordable in absolute, besides technically very hard to be maintained. The cost, for six months, using e.g. steam technology to make vacuum[29], would be in the order of the hundreds of million Euros.

On the Moon, vacuum is fully free of charge, in an environment offering solid ground under feet. The low gravity of the Moon is not zero gravity, of course, but it can be used for many tests, and zero gravity, in Moon orbit, is very much easier to reach from the Moon ground than from the Earth's surface. A wonderful, cheap and easy, test environment! Something that the planning of scientific missions, financed by public money, could find not so relevant. While entrepreneurs, limited by budget availability and ROI times calculations, will surely pay the due attention to such conditions. The question is always the same: do we only aim to *play with space, satisfying our scientific*

curiosity, or are we serious? If we are serious, Moon is the obliged next step of our road map.

The preferred place for complex extraterrestrial advances both technologically and socially

In several papers[30], Krafft A. Ehrlicke describes how and why the Moon is the best place we could expect, to move our first steps outside of our Mother Planet. Paraphrasing the language used by some very religious people, we could say that "If The Lord wanted us to travel in space, He had given us the Moon around Earth, as a school classroom and gymnasium"!

"Low gravity, vacuum, absence of "Weather" support both slide landing and the DDM (Drop Delivery Method); in addition, certain lunar surface structures (Mare areas) support high-speed landing.

(...) The vacuum allows high-speed approach to the surface without temporary communication blackout due to ionised boundary layer formation. Absence of aerodynamic effects, superb sky and ground visibility (including optical signs at night) permit high predictability and automation of approach navigation."[27]

The absence of aerodynamic heating greatly simplifies the design of spacecraft targeted to the moon landing.

Moon yards will allow the maintenance of spacecrafts, in an easy way. Everything will weight just a sixth of its Earth weight, and at the same time it could be very convenient to can use an environment where, anyway, liquids fall to down, things can be supported (and don't need to be tied, as in full absence of gravity), and so on. Most of all, *it will be a step*, not completely different from Earth conditions, allowing thus to make precious statistical experience. What the industrial age taught us is that quality and safety only can come from cumulative experience, that allows to calculate *statistical data*.

At the same time, we need to start what Ehrlicke called *industrialization* of the Geo-Lunar system, i.e. to begin productive and profitable activities out of Earth. Moon is the best place to do that.

"On Earth the biosphere was first. On the Moon, the Human his first"[30]. This condition makes of the Moon an incomparably favourable situation, where Man can learn to build artificial ecosystems, start intensive extraterrestrial agriculture, cumulate statistical data about exo-industrial, exo-economic development, and *exo-sociologic development* as well. The buildings construction work is greatly facilitated by low gravity, and centrifugal gymnasiums will be enough to oppose the physiologic effects of the Moon low gravity.

Ehrlicke gave a key relevance to the Moon, in his accurate general plan for Humanity to become a multi-planetary Civilization. In the same paper already mentioned[30] he speaks about the *"industrial lunar factor"*, listing 5 items, synergically working in the Geo-Lunar System (ALPRM): A – Application Satellites, L – Light, P – Power, R Raw Material Extraction, M – Manufacturing.

One of the most important opportunities, given us by the Moon, is the possibility to experiment exo-sociologic conditions, by an increasing number

of people, living and working on our natural satellite. That will be possible earlier, than if we had to build the O'Neill artificial platforms starting from Earth' surface! When the O'Neill cities in the sky will be possible, we will already dispose of a huge statistical experience, and rich stories, about people living outside Earth, on *Selenopolis*.

A detailed list of Lunar Products is provided in [31]: "raw stock from mining and refining, and a vast number of semi finished and finished products: sheet metal and trusses of aluminum, magnesium (titanium, iron, or alloys; castings, bars, wires, powders of pure or alloyed materials; glasses; glass wool; ceramics; refractories; fibrous and powdered ceramics; insulation; conductors, anodized metals; coatings, including almost perfectly reflective sodium coating (since sodium can be freely used on the Moon and in orbits, whereas on Earth it reacts with water and is dulled, by oxidation and therefore generally unsuitable); thin film materials; silicon chips; solar cells; entire structures of various metals and alloys for lunar and orbital installations (they do not have to be made weather resistant); compound and fibrous materials; heat shields and insulation materials, as well as radiation shielding materials for space stations; propellant containers; entire orbiting facilities, such as space station and factory modules and liquid lunar oxygen depots; large portions of cislunar and interplanetary spacecraft; and so on. Where zero-gravity is required for the manufacturing, easily reached facilities are available in circumlunar orbit (CLO) for manufacturing crystal bole, fibers, solar cells, and other special materials and products whose manufacturing requires' gravity levels below lunar, which is already low enough for many products. Parts, components, sub-assemblies, and full-assemblies can be integrated in CLO before being shipped to geosynchronous or other distant circumterrestrial orbits by means of electric freighters, whose thrust acceleration and propellant consumption are very low. Eventually, they will use lunar sodium as propellant."

Relieving the human pressure on our planet

Earth is not sick: she's pregnant!

What would happen if you build a normal house, with doors two meters tall, and ceiling at 2.50 m., and your son grow up to 2.10 m? Of course it's a problem: he will be constrained to flex his neck each time he must enter a room, and you will have problems finding shoes, and trousers, and all clothing, of his measure. Likely everything will cost more than normal size, not to speak about feeding such a giant!

In few words, when you speak alone with your wife (or husband) you will maybe confess that the "boy" is *unsustainable*, and let's hope that he will soon find a job and start living on his own means and resources.

Surely – except you are an awful parent! – you will not charge him of "*being grown too much*", or "*eating exorbitantly*". And surely you will not continuously exhort him to reduce his dimension.

Believe me or not (I am talking to an imaginary extraterrestrial visitor ☺), the above recommendations are exactly what many "awful

parents" are administering to our youth, the humanity's "big boy"! What should we do, instead? Obvious: to enlarge our home, or to help our big son to build a bigger home.

A better metaphor, very much more evocative and self-explanatory, is the one of the Pregnant Earth[32]. "A *pregnant woman*" writes David Butth[33] "*experiences unsustainable growth in her abdomen. Similarly, the Earth is experiencing unsustainable growth of the human population. A pregnant woman experiences changes in her body chemistry. Similarly, the biosphere is experiencing changes in air and water chemistry as a result of man-made pollution. Pregnancy and birth, particularly before the advent of modern medicine, can be a very dangerous time for a woman. Death of the mother and/or the child was once quite common. Similarly, nuclear weapons, pollution, and other problems threaten civilization (although the biosphere has survived much worse). A wise woman treats her body with extra care during pregnancy – eating well, getting plenty of sleep, avoiding drugs, and seeking appropriate medical attention. The implications for ourselves are obvious, especially since that there are no experienced doctors or midwives.*"

The most important and meaningful aspect of this metaphor is that a pregnancy is a process, that shall have an end, possibly a happy end, and not a tragedy. The end of the Mother Earth's pregnancy will be the birth of a Baby Solar Civilization, settled on Earth's orbit, on the Moon, on the Lagrange points: the nursery. Then, when the baby will be grown up, maybe the Solar System will not be enough! But that one will be quite another time and another history.

The space aid to recover our planet

Space does not have only gifts for humans, but also for the nature of this planet. There are no chances, for us, to recover the ecological system of this planet by remaining confined on this planet. Our only hope to complete this task, or at list to try helping such a process, is to become a multi-planetary civilization. Only so we will make the needed experience of artificial ecosystems on orbital platforms and on planetary settlements. If we want to have a chance to understand how the organic systems work, we shall reproduce organic (Earth-like) systems in small, *starting from scratch*, and adding one by one the Earth conditions: artificial gravity, then air, then chemical components. Space is important because it supplies the environmental conditions that we cannot find here, at the bottom of the Earth gravitational well:

- absence of any chemical components, absolute sterile environment;
- the vacuum (to realize a vacuum chamber on Earth is a very hard and expensive thing, while in space it is free of charge!);
- boundless space, in order to setup as many experiments we deem needed, without spending a cent more;
- whole worlds fully or almost fully sterile (Moon, Mars, other planets), where we can start from dead dust, preparing small fertile areas and *bootstrap* the process of life.

Nowadays we understand absolutely nothing about the ecological global processes, at planetary

level: we are hardly able to make realistic weather forecasts. We stammer about "greenhouse effect" and about a supposed impact of human activities, which would increase such a process. We give for discounted that temperature will grow up continuously. But, provided that our activities really affect the ecosphere, the global ecosystem' reaction is far from predictable. Just as an example, let's suppose, like David Buth states in his paper[34], that Gaia works like a giant, self regulated, continuous feedback process (a fascinating hypothesis for me, being professionally a process control systems designer). If it is so, the Earth continuous process control system has a somewhat *setpoint*, to reach or to keep: the more we will heat the environment, the more it will work to cool it. So, provided that we are really having an influence on the global climate, we should maybe expect more a new glaciation, rather than a greenhouse!

However, whatever the impact that we could or not have on the Earth' ecosystem, our growth in a closed environment is no more sustainable, not only by the planet, but by us humans, first of all.

Therefore I maintain that, once we will be in safe, soundly settled on extraterrestrial Solar System resources, and the progress of our Civilization will be surely restarted without possibility to fall back, one of our priorities should be to recover the damages we made on our Mother Earth. Not before. As I said, we will also have better knowledge, to do it better. I'm sure any Mother would understand and agree.

ACRONYMS

Acronym	Description
ETO	Earth-To-Orbit
FIPES	Facility for Integrated Planetary Exploration Simulation
FIRST	Far-Infrared Space Telescope
ISRS	Inflatable Space Rigidizable Structures
ISS	International Space Station
MIR	The USSR' space station, that remained in orbit 15 years, from February 1986 to march 2001
NASA	National Aeronautic and Space Agency
SPS	Solar Power Satellite

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