

How the 21st-Century Society Can Sustain the Implementation of the Space Option

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Abstract

A reasonable-sounding argument used by the adversaries of the space option is that of its "enormous costs." The implementation of the space option call for investments that are comparable to those directly needed to satisfy the needs by purely terrestrial means, but with significantly lower follow-on costs (decommissioning, etc) expected because of the separation from the biosphere and of the high amount of reuse postulated by current economic models of space industry. Against the direct expenses one must account the losses incurred when terrestrial development project are killed because of extended environmental considerations: missing economic returns, social development losses, impoverishment and associated imposition of political burdens. The systems thinking of the space option must be used to (i) convince governments to apply resources to areas that (a) contribute to solve actual problems and in which (b) private investments are scarce, while (ii) pushing investors to finance space enterprises for their own opportunities.

1 Introduction

During the last few years, the Space Option has been researched as a dual concept for making possible a humane future through a proportionate "space" development. Thus, for the benefit of the space community, the space option concept was defined from an analysis of the wealth of rationales for Astronautics vs. the dwindling societal support for these activities (Bernasconi & Woods, 1993a, b): it was shown that at least part of the present disaffection is due to the current policy actors' rejection of the historical motivations of the Astronautical movement and that the space option represents the "new space program" to bring space back into the national agenda (Bernasconi, 1995a).

But the space option also surfaces as the practical handmaiden of the Astronautical Humanism, introduced as a "balance point" world view between the two poles of economic conservatism (business as usual - bau) and the growing ecozist menace. Ecozism has succeeded in becoming the most pervasive ideology in the current mainstream thinking: it is a totalitarian, "postmodern" doctrine rejecting humanity and raising "nature" to the supreme

good, with the striking characteristics of an active adherence to antiethics, masked by the projection of an ethical-like smoke-screen. Being anti-scientific, it negates (essentially by ignoring them) any quantitative assessments, relying instead on disjointed acts of ideological "faith" (Bernasconi, 1994; 1995b).

The futures analysis unveils models near either pole as authentic "recipes for failure," given that both tend to ignore physical reality as if a negligible feature, economists being as blind to sociopolitical forces much as ecotists are to economic aspects.

To research the quantitative need for the space option, the basic demands of the 21st century's humanity have been reviewed: for the example of the food production, it was found (Bernasconi & Bernasconi, 1997) that it would be physically possible to sustain a 10-billion human population within the Earth's biosphere, even though such a level is about two orders of magnitude above the "natural" population for this sort of mammal. But, since this task will require husbanding a fraction significantly greater than one-tenth of the total biosphere's production flow, it must be understood and accepted from the outset that large dislocations within wild environments are unavoidable, that the risk of collapse is significant, and that it would be a wise tactic to rely on this single biosphere only as briefly as absolutely necessary.

As one orients the analysis away from basic demands for sheer survival and towards more civilizational requirements, the situation worsens: the human impact (within the scale of the biosphere -- currently our sole ECLS system) increases by orders of magnitude over the strained food-energy one: exosomatic (or industrial) power usage is higher by 1-2 orders of magnitude than the metabolic power level. While this fact is known enough to be served to biology students (see eg Czihak, Langer & Ziegler, 1976), still it remains uncomprehended by most researchers. The physical importance of the demand for power would be sufficient reason to make it the leading product from the implementation of the space option, but other technical realities further strengthen its force (as outlined eg in Bernasconi, 1994a, 1997b). An additional ethical reason to focus on the energy supply to human society is finally given by the need to respond to the demagogical ideological ecotist intent, namely that the access to power ought to be restricted!

Thus, as one moves farther from "zoological" necessities, the Astronautical Humanism principle shows the space option concept originating from a complete system-approach to future human problems, that demand concerted considerations of connected -- not isolated -- needs and applications. Of course, a successful market implementation of the space option will require analytical tools, to dissect concepts, goods, and activities that become products of diverse enterprises -- but at present, our work remains focused on the integral relationship between Astronautics and Society.

2 Financing the Space Option

A reasonable-sounding argument used by the adversaries of the Space Option is that of the "enormous cost" that renders such an endeavour unaffordable.

2.1 The Needs

In a previous paper (Bernasconi & Bernasconi, 1997), we quoted a list of needs for the human enclaves, with a nominal population of ten billions, i.e. the level that will be roughly reached within a generation:

1. space and shelter
2. water and food
3. energy supply
4. materials supply
5. aesthetics -- or at least absence of nuisances
6. nontoxic waste and by-products

Table 1 offers a rough summary of the aggregated demands of humanity, a generation from now. The data for water and foodstuffs needs were analyzed by Bernasconi & Bernasconi (1997), where a summary of the energy discussion was also included. More data on non-fuel matter manipulation has been added here, building upon the discussion of demandite as reported by Criswell (1981). The shelter requirements have also been estimated, starting from the need to add a 5-billion individual capacity over 30 years; given that the actual need is greater in absolute and that renewals and substitutions are continuously necessary, this value is at the lower end of the scale, as the comparison with the construction materials flow from the demandite's breakdown corroborates.

That this estimate must be a lower bound is also due to it including only residential housing (no consumption for infrastructure, economy building, public and government usage, etc.). The modesty of the approach is checked by a look at the average population density that results from the associated land use estimate, value that is comparable with that for Hong Kong.

Then, the recreational space value must be seen as a (much too) low bound as well (the equivalent population density amply exceeds those for the Agency's Member States - though it is surpassed by India's).

Use / Commodity	Net Global Need	Global Production Equivalent	Cost	Fraction
Water	18,250 km ³ /a	18,250 km ³ /a	-	16.78%
Human Nutrition	1.3 TW	10.59 TW	-	10.38%
Habitat space - shelter	> 1500 km ³ or > 600,000 km ² floor area	0	~\$180,000 billion or ~\$6,000 billion/a	-
Habitat space - land use	> 1.8 million km ² (5555 person/km ²)	< 148.9 million km ²	-	1.2%
Habitat space - recreational space	> 18 million km ²	< 148.9 million km ²	> \$800 billion/a	12%
Matter manipulation	532048 million t/a	-	\$24,960 billion/a	-
Building materials	20,000 - 244,742 million t/a	-	-	-
Metals	5000 - 31923	-	-	-
Power generation for matter manipulation	21.4 TW	21.4 TW	-	21.0%
Power generation - fuel equivalent	239422 million t/a	136 TW	-	(133%)
Power generation - net	30 TW	150.5 TW	~\$13,000 billion/a	-
Total - wrt Primary Production	-	11 + 150 TW	> \$44,760 billion/a	11%, 147%

Table 1. Biospheric Burden & Economic Basics for Hosting the 21st Century Human Population

The widest discrepancy was observed between the demandite time-series model and an independent modeling for the non-fuel materials. Table 2 projects the production requirements for a few elements for a globally industrialized, post 2030 society: the specific needs have been estimated from the US figures, basing on USGS data. The use of these terms is justified also by noting that the resulting specific values are rather stable: over the 29-year span between the 1968 data, reported by Caulkins (1977) and the 1997 results, the widest shifts are 59% (increase, for copper usage) and 55.9% (decrease, for molybdenum). One notes that the aggregate value of the yearly production of these fourteen elements alone is of the order of a trillion US dollar: Goeller & Zucker (1984) estimated the capital investments necessary to comply with a similar demand volume at some \$5 trillion.

The aggregate metals amount from this assessment is clearly smaller than the allocation from the demandite model. In part, this may be due to having considered only the apparent consumption of metals as products, and not their overall usage, e.g. including imported (semi-finished) products, or the role of additional consumption outside the US, within the framework of a global distribution of labor; in part, this may also be evidence of a change in consumption pattern (note, however, that the stability of the per capita use of iron over a thirty-year period rather argues against this explanation). Also noteworthy is that for half of the elements for which the data are available, the reserves would be depleted before 2030, fact that only emphasizes the fragility of the business-as-usual approach. Conversely, the coal-fuel equivalent from the demandite model agrees well with the global equivalent of the power use projected in our independent assessment.

In conclusion, to provide for shelter, non-fuel materials, and power for the 2030 world population, expenses of some \$45 trillion per year will be necessary (for comparison the US GNP -- with a forty-time smaller population -- now exceeds \$8 trillion), or \$4500 per capita.

Element	1997 World Production [million t]	2030 World Production [million t]	*Recycling Price [1997\$/kg]	Production Increase [-]	2030 Production Value [billion \$]	Current World Reserves [million t]	Depletion by 2030 [million t]	
Aluminum	21.2	218.0	25%	1.70	10.3	369.7	-	-
Copper	11.3	86.8	15%	2.33	7.7	202.7	950	140%
Zinc	7.8	60.3	8%	1.72	7.7	103.5	620	162%
Iron	1030.0	3283.2	7%	0.03	3.2	98.5	180,000	64%
Nickel	1.1	6.3	39%	6.93	5.9	43.8	180	60%
Lead	2.9	51.8	68%	0.84	17.9	43.3	185	151%
Silicon	3.2	24.0	-	1.37	7.5	32.8	unlimited	-
Manganese	7.5	39.5	-	0.59	5.3	23.2	5680	13%
Chlorine	48.0	424.6	-	0.05	8.8	19.5	unlimited	-
Sulfur	54.0	502.3	7%	0.04	9.3	19.1	4900	169%
Chromium	12.07	19.7	24%	0.90	1.6	17.6	11000	4%
Magnesium	0.336	6.3	16%	2.70	18.6	16.9	unlimited	-
Titanium	0.08	1.2	24%	9.70	15.0	11.6	-	-
Molybdenum	0.1	0.7	9%	8.5	5.5	6.1	17.5	71%

Table 2. Production Requirements and Value of Selected Non-Fuel Elements

2.2 Terrestrial Options?

Energy has been and remains the commodity of choice for early extraterrestrial resources utilization because of its intrinsic significance for all processes, of the sheer amounts that will

be needed in the next century, and of the associated issues of source availability and of biospheric consequences. Furthermore, abundant and benign energy sources are urgently needed to thwart the ecozist domination and the resulting human suffering: under the pretext of "negative environmental impact" and "scarcity" of energy, ecozists wish to reduce at least the specific use of power for industrial purposes.

Kümmel (1981, 1985) has discussed the impact of energy usage on the production curves for the US and Germany in the 1960-1980 period by expanding traditional economic production functions to account for energy (E), in addition to capital (K) and labor (L). The results of his work have been used to compare the production and productivity trends over a 33-year period (eg 1998-2030). For simplicity, the growth factors for the three input parameters have been kept at an average value over the interval: for capital and energy, the growth reference case uses 2.13% and 1.42%, or the values observed between 1970-1978 for the US industry. (Note that this period was affected both by the "energy crisis" induced by OPEC with a subsequent recession and by the attempts to minimize energy usage to reduce the economic impact of the higher prices.) For the labor, under consideration of the massive population increase that will occur in the future, a doubling of the work force of the interval analyzed was imposed, resulting in a 2.12% growth rate. Four cases are compared in Figs. 1 and 2: in addition to the described reference, the ecozist solution to hold constant the global energy consumption was considered, as well as an optimistic (and therefore labeled with "space option") case with twice the energy growth rate of the reference case. Fig. 1 illustrates the obvious consequences, the a stagnant production under the ecozis' rule and a robust growth when sufficient energy is accessed (computed by a Cobb-Douglas equation (using the results of the analysis of Kümmel, 1985 -- refer to the text for details of the models).

But a more realistic representation is given by considering the productivity, as shown in Fig. 2, where the meaning of the "constant-income" label is made obvious. Already in the reference case, production cannot keep pace with the population growth, and the yield per worker declines: even the apparent strong growth of the high-energy case increases the per-capita wealth by less than a meager 20%.

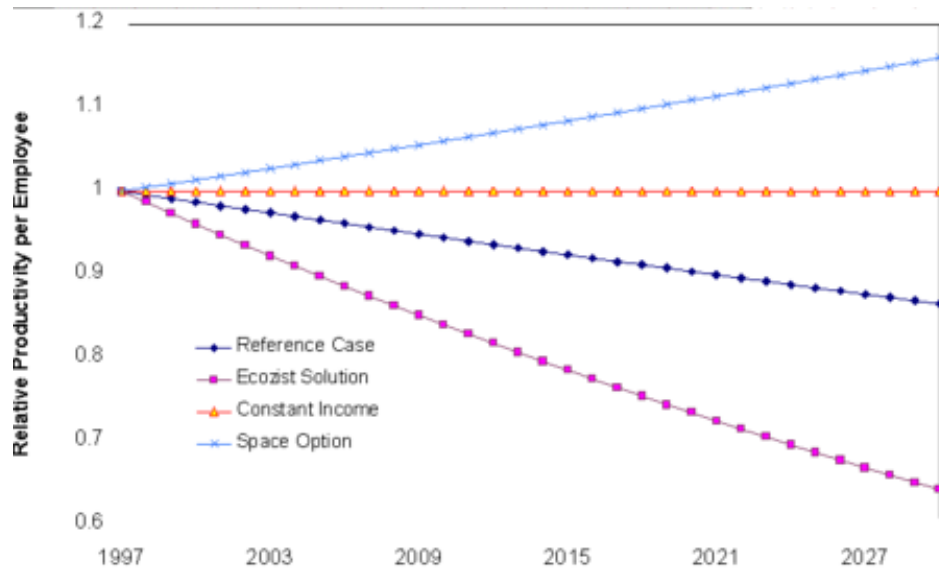


Figure 1. Impact of energy availability on the evolution of industrial production

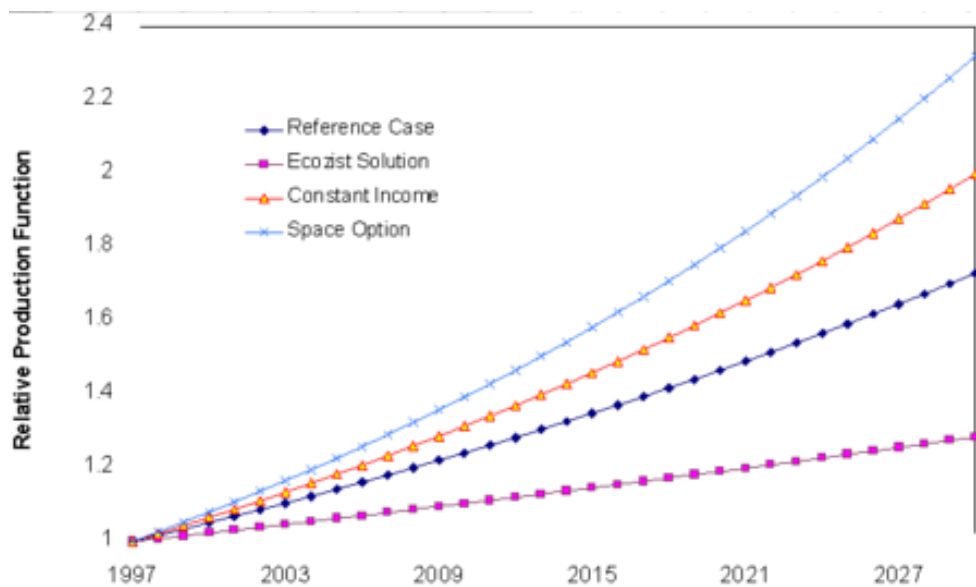


Figure 2. Analysis of the production output per employee following from the computations shown in Fig. 1 (refer to the text for more details)

How much is the benefit of making available even a modest increase in energy? At the end of the period, the distance between bottom and top curves corresponds to more than 100%, or Q_0 , ie the production in the reference year, or some \$20 trillion for the world's economy. O'Neill (1978) estimated the investment for the realization of space manufacturing facilities for the production of SPS at some \$0.118 trillion.

Indeed, system-oriented analyses for space power systems have repeatedly shown that:

- the projected unit costs are comparable to those of high-quality ground-based systems
- only the acquisition of power from space can provide for a sound economic substrate

- direct environmental impacts are the smallest of any power generation option
- power from space moves energy supply to a new qualitative level through a "global electrification" and the elimination of a large fraction of chemical and nuclear pollutants.

2.3 The Cost of Surviving

In reality, the implementation of the Space Option call for investments that are comparable to those directly needed to satisfy the same or similar needs by purely terrestrial means. Furthermore, the follow-on costs of such investment (e.g., decommissioning, etc.) are increasingly seen as the most significant part of the expenses, and governments are increasingly demanding that they be factored in any planning: when such extended envelopes kill a development project, the modest initial saving are overshadowed by the sum of: missed opportunities for economic returns, outright losses in society development and impoverishment-imposed political burdens. In comparison, the restoration costs for space-based enterprises are expected to be significantly lower, both because of the innate separation from the biosphere and because of the amount of reuse postulated by current economic models of space industry.

3 Conclusions

Elsewhere, it has been shown repeatedly (Mitchison, 1993; Garrett, 1994) that significant risks exist for the apparition of health hazards that would be uncontrollable and fatal for a species overfilling this planet. Elsewhere, it has been shown (Bongaarts, 1994; Smil, 1997; Bernasconi & Bernasconi, 1997; Criswell, 1997) that, while physically possible, to feed the next century's population will definitely strain the Earth's biosphere -- and in addition, doubts have been expressed (Safina, 1995; Brown, 1996) about the fact that what is physically possible on an integral level can be done in the actual locales. It has been shown repeatedly that no other power source is today available but the Sun that can comply with the requirements of the 21st century humanity's, and that all other approaches but space power are burdened by chemical or physical pollution loads, or both (Criswell, 1984; Bernasconi, 1994). It has been shown repeatedly (Ehrlicke, 1972b; Goeller & Zucker, 1984; Bernasconi & Bernasconi, 1997) that a number of mineral resources may be depleted within the next century. It has been reasonably & powerfully argued (Ehrlicke, 1970, 1972a; Michaud, 1977; Bova, 1981; Sheffield, 1986; Bernasconi & Woods, 1993b) -- with the continuously growing support of daily observations -- that the single-human-planet will become as a matter of fact and "for the best of reasons" a site of total conferral and global oppression.

Reality confronts us with a strained, impoverished, and disenfranchised humanity struggling to survive in the present political and economic climate: and yet the simple "Open World" approach continues to be discarded because of the perception of "excessive costs." The costs have been shown repeatedly to be reasonable fractions of the necessary world's investments; the efficacy of these investment's fractions has been repeatedly shown to surpass other forms' as success surpasses failure (Kümmel, 1981; Martin, 1984; Yamagiwa, Kaneda & Ishikawa, 1994). Again, we show here that (even neglecting the decay that would be the consequence

of business-as-usual, single-planet policies) the benefits of taking the space option are huge, even over a time scale of only 30 years.

Those who continue to refuse to open their intellect to the ethical imperative of the extraterrestrial imperative will have to take on their conscience the full burden and this refusal. And those that continue to oppose implementing the space option out of their small-heart fears have only one possibility to escape the scathing judgment of History: that nobody will be left to tell the story of their coward failures. Acknowledgments

This paper presents the results of independent work done by the author, who would appreciate receiving your comments and thoughts on implementing the space option concept as the first step towards an Astronautical Humanism. You are invited to forward any comments to: gordon@bathome.org

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