The Space Colonization of Planet Earth

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Planet Earth is a small, slowly rotating, water covered, rocky and metallic terrestrial planetary body, orbiting at the near edge of our sun's habitable zone. Earth's axial tilt produces pronounced seasonality, an active hydrological cycle, and large polar ice caps. It possesses a modest atmosphere of molecular nitrogen and oxygen, well mixed at a ratio of four to one, with abundant water vapor, trace inert gases and biologically produced industrial and greenhouse gases, including the vitally important climate and temperature regulator and primary plant nutrient – carbon dioxide. The solar irradiance received at the surface of the Earth is approximately one kilowatt per square meter perpendicular to the plane of flux. At high latitudes the most immediate threat to survival is the onset of hemispherical seasonal cooling – winter. Extreme arctic conditions and heavy snow cover results in a complete shutdown of agriculture.

In this paper I describe the basic survival needs of a single human being at our current technological level of understanding, predicated towards an average latitude of 45^{o}. I assume this to be single family, mobile, land based living, in an electric automobile pulling a trailer. Utility trailers are fairly common, but are far too heavy for efficient towing. Consider rectangular boxes of variable wall thickness. For a minimum insulating wall thickness of six inches of high density extruded polystyrene foam insulation, using standard 2 or 3 inch sheets, a 4 by 4 by 8 foot box will yield a 3 by 3 by 7 foot sleeping space and an 8 by 8 by 8 foot box will yield a 7 foot living space, enough to stand up and lay down comfortably.

Foam boxes of this nature can be hand assembled from precut boards, sandwiched between inner and outer liners of rigid polyethylene sheeting, using self locking plastic 'tie wires' and 'latch washers' with plastic extruded angles for the inner and outer edging. Diagonally tensioned plastic nylon rope or wire will prevent the deformation of the structure under wind loading. Tyvek wrapping is applied externally. This strong and lightweight rigid rectangular box can then be secured to the trailer or the ground with cables and anchors, and further insulated with bales of hay or straw, or bags of dried deciduous leaves. The trailer itself may further covered with solar panels and transported by hand, by beasts of burden or by electric vehicles, on roads or over rough terrain, and made available for difficult to institutionalize homeless, or in small villages of 'tiny homes' where public restroom and shower facilities are available. It may even be disassembled, stored flat for transport and then reassembled again at its new location.

In small tightly sealed spaces carbon dioxide management becomes an important issue, and thus air exchangers and breathing snorkels must be used to prevent carbon dioxide poisoning during sleeping. On the other hand, carbon dioxide starvation of plants becomes immediately apparent for grow rooms. Small computer fans are adequate for air displacement and thermal management. Given the insulation efficiency, small insulated box refrigerators, freezers and air conditioners can be provided passively and using new thermoelectric devices. Water may be stored in mattress bladders or simple plastic containers and comprises most of the weight of the habitat, unless supplied externally. Natural materials such as cotton, lightweight ordinary polyester pillows and inflatable cushions may be utilized for user comfort. Thus, with the exception of the axles, wheels, bearings, suspension and bed, the entire system is plastic, greatly reducing its weight and cost, ease of manufacture and fabrication, and its simplicity and utility.

Hatches, windows and vent plugs are beveled in for ease of installation and removal and to provide a variety of configuration options, the most obvious being the folding out of the large solar panel arrays covering the box, and supporting them as porch awnings, sunshades and rainwater collection surfaces, greatly increasing the outdoor habitable living space surrounding the automobile and trailer box habitat. Simple glass and plastic solar stills may be transported on top of the trailer box and then set out for use.

The creative engineering and design of the interiors of these larger foam box habitats are capable of reproducing modern kitchen plumbing and bathroom sanitation functionality for total self sufficiency. The 'Earth Home' concept is the insulated foam box extended to large heavy immobile thermal masses, primarily steel reinforced concrete earth berm structures with a large attached south facing greenhouse. Greenhouses and windows in such a structure would be insulated nightly with removable foam boards.

Consider the minimum hydroponic plant growing system for such a small space or structure. Assuming ambient light and one Earth gravity, small opaque white polypropylene plant containers such as 16, 24 or 32 ounce cottage cheese or yogurt containers, 1/8" black molded polyethylene fittings, ¼" hard poly black tubing and pulley suspended, commercial 3 to 5 gallon square or round pails produce a quick and inexpensive, easy to assemble, gravity fed hydroponic plant growth system. The only specialized tools required are a 1/8" national pipe thread tap, and a sharp drill bit to insert the fittings into the containers, and possibly a hand operated press to connect the tubing segments into the nutrient distribution system. Clear flexible laboratory tubing may be substituted for the harder plastic tubing but is less than optimal. Basic hydroponic units such as this may easily be automated by simple motors, controllers and sensors, and operated by elementary, middle and high school students, providing an excellent introduction to STEM topics as diverse as engineering of simple machines, electricity and electronics, optics, physics, chemistry, biology and ecological systems. Plants require heat, light and carbon dioxide and provide the quickest route to solving severe technical challenges of closed environmental life support systems.

Primary plant nutrients include potassium mono and dihydrogen phosphate and potassium nitrate, calcium nitrate for double nitrates, magnesium sulfate (epsom salts) and possibly potassium sulfate. Trace metals boron, manganese, zinc, iron, copper, molybdenum etc., may be provided by sulfate salts. Nutrient salts are rendered graphically as dual triads of potassium, calcium and magnesium cations and as nitrate, phosphate and sulfate anions, and their molar concentration calculations are straightforward. Plants produced in this manner may be composted with grass and deciduous leaves to produce humus. Any excess nutrient solution runoff or waste can either be recycled or used directly as fertilizer water. Phosphoric, nitric or sulfuric acid are used for pH and turbidity control (calcium sulfate precipitation).

In a slowly warming world, many deciduous nut and fruit bearing trees will be necessary to moderate the temperature, absorb excess carbon dioxide, feed the local wildlife and produce leaves for compost. Open spaces between tree stands can provide brightly lit garden areas and orchards for food production. Corded electric 'horsepower class' tillers and mulchers will greatly increases garden labor productivity, and can be run directly by small local wind generators, solar arrays and energy conversion electronics. Water storage can be provided by 55 gallon blue plastic barrels or concrete cisterns within earth homes, and rainwater collection surfaces can be glass greenhouse panels or solar panels for energy production.

Electric car battery banks can provide the initial robust energy storage capabilities until they reach their charge limits, and once degraded they can be moved to permanent solar and then wind energy storage, where generally the energy is used directly, and the batteries serve more as buffers rather than storage. Once fully degraded or inoperative (shorted out) they can be recycled. Properly designed high wind, high speed wind turbines can deliver three phase power directly to three phase motors such as tillers, mulchers, washing machines, or any application where RPM and voltage are not particularly critical.

Near term condensed matter or solid state physics advancements that will enhance this general scenario include cubic and hexagonal nanodiamond films for electronics, light strong and non-toxic aerogels for thermal insulation, nanostructured thermoelectric devices for refrigerators, freezers and air conditioners and novel and unique new materials for topological insulators, superconductors and exotic electronic phenomena such as ultraviolet lasers, LED optics, defect states, spintronics and multiferroic devices.