

Keep it clean!

NASA's International Space Apps Challenge 2014 project
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Acknowledgements

NASA's International Space Apps Challenge 2013 solution winner **Space Veggies** constitutes the basis for the solutions and suggestions within this project. The design ideas proposed in the **Space Veggies** solution have not been changed in this project unless mentioned otherwise. In addition the **Space Veggies** project serves as an inspiration and set the bar for us who follow.

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Aims

The aims of this project are:

- 1). to discuss the phytosanitary issues of greenhouse facilities designed for Mars
- 2). and to propose additional ideas to supplement the original NASA Space Apps Challenge 2013 solution winning project **Space Veggies**.

Problems facing Marsian greenhouses

Contaminations and outbreaks of plant diseases cannot be ignored while planning for a working greenhouse facility. Though the inputs of contamination are reduced significantly compared with greenhouses on Earth the risk still remains. For example spores of fungi and endospores of bacteria can survive lengthy periods of time without a favourable environment for growth. Not only materials destined to be parts of a greenhouse possess the risk of being sources of contamination. The dormant structures can hitchhike their way in seemingly harmless structures and objects. In favourable conditions the dormant spores and structures come to life and flourish, possibly even leading to a catastrophic epidemic of plant disease. Unlike on Earth there are limited outsourcing possibilities on Mars for new parts not to mention seeds or healthy plant tissue in case of a problem.

Suggested solutions

With the problems in mind the following suggestion and solutions categories are discussed:

- 1.) Additional design ideas for greenhouse blocks.
- 2.) Phytosanitary guidelines are outlined.
- 3.) Suggestions on retaining the positive psychological impact.
- 4.) Additional suggestions to further diversify the fresh diet.

Greenhouse design

In the original **Space Veggies** project greenhouse compartments were designed to be connected into large open areas. This should be reconsidered due to at least the following reasons:

- 1). Connected blocks enable the spread of possible pests and disease.
- 2). Connected open blocks make containment of surfacing problems (biological or technological) difficult.
- 3). Replacing plants and growth systems is difficult to impossible.

To reduce risks in the greenhouse blocks it might be advisable to favour closed individual blocks instead of open blocks. Individual blocks with separate control systems would help containing problems in smaller areas. Separate control and sensor systems would confine any technological problems to one block. Sensory system could include electronic noses capable of sensing volatile compounds created by the plants in addition to the basic light, moisture, pressure and heat sensors. This way any outbreaks of disease or other biological problems could be detected early on. Electronic noses could also be utilized in addition to visual cues determining the right time of crop harvest.

Primary production could be kept more separate if greenery is introduced into the main living areas through containers or small portable greenhouse units. For the large greenhouse blocks used for food production it would be less risky to keep them separate.

Interconnectable greenhouse blocks could be made safer in terms of hygiene if they included a separate space prior to the entrance into the actual cultivation area. This space could be used as storage for instruments and protective clothing. It would also function as a barrier for contaminants and as a logical area for control panels. Greenhouse blocks could still be designed so that they can eventually be opened and joined into larger blocks. This could be useful when colonization of Mars would be well underway and blocks would be more numerous. At the starting phase of colonization it would be foolish to so to speak have all eggs in one basket.

Creating organic matter for cultivation media might not be necessary but could be useful when expanding plant production. Wasting any usable material should be avoided whenever possible. This advocates the use of composting proposed in the original **Space Veggies** solution. In addition biochar, pyrolysed biomatter used for soil amendment (IBI 2014), could be considered as an option or to complement composting. Compost could serve as a media for other cultures, such as fungi, but it contains some plant health hazards if not properly treated. Should composting be the chosen method to reuse plant waste, it should be done in closed facilities so that only sterilized end product would be handled. Possible micro-organisms could be added in the process of soil mixing but finding the right micro-organism cocktails might prove difficult.

Outer layers or rows of greenhouses could be used in algae farming. Any possibilities in sourcing renewable energy should be considered. Algae containers could be used in harvesting radiation and transforming it to storable forms of fuel such as biodiesel and hydrogen. The fast growth rate of microalgae would make it more expendable than seed grown plants and thus more usable in harvesting solar energy through direct exposure to radiation. Algae tanks could be used both as a source for energy but also as radiation shielding.

Phytosanitary guidelines

Mars facilities are a closed system and this increases the need for a set of guidelines to be followed. Help and replacements are far away. Perhaps the greenhouses should be considered more as vulnerable laboratory experiments than anything more robust. Phytosanitary measures could follow biosafety guidelines for GMO laboratories (discussed by Kimman et al 2008) and research facilities.

Phytosanitary measures and guidelines might include the following points:

- 1). Instruments used in one greenhouse block/compartment should not be removed or used on another area without sterilization.
- 2). Good hygiene should be maintained while working in greenhouse blocks. Good hygiene includes among other things cleaning of any spills, avoiding spread of any possible contaminants within a block and using clean instruments.
- 3). Visits to greenhouse blocks should be restricted to one block on daily basis to decrease the likelihood of spread of contaminations.

- 4). No handling of unsterilized compost in any facilities.
- 5). Protective clothing should be advisable with same rules applying to instruments.
- 6). Rotation of blocks in cultivation and in cleaning mode. After harvesting crops (edible or seed) the block should undergo maintenance cleaning and sterilization. Timing of cultivation should allow continuous harvesting while maintaining good hygiene.

Keep smiling

With the problems and restrictions described above there is definitely a need for greenery in living environment in order to maintain the mental health of Mars pioneers. Caring for living creatures allows relaxation and a sense of familiarity in otherwise alien environment. Due to this, keeping the greenhouse blocks accessible is of outmost importance. As mentioned already in the original **Space Veggies** solution, work done in greenhouses could be restricted to harvesting. In addition some maintenance functions would have to be performed by humans especially in unexpected situations. These functions might include seed harvesting, propagation to some extent and taking care of any technological problems not repairable by the system itself. Need for human intervention should be minimized.

Aeroponic systems could be re-shapeable, meaning that their structure could allow parts of the system to be manouvered both horizontally and vertically. This would allow creativity and the possibility of even green art while still remaining productive and functional. Creativity on its own helps maintain mental health (Cropley 1997) and greenery has been proved to increase sense of well-being (Velarde et al 2007).

Smaller closed greenhouse units could be integrated into the common living habitats as houseplants. This could reduce the need to visit the greenhouse areas. The greenhouse units in the common areas could also include containers supporting algae meant for specialized products such as proteins, medicine or fuels.

What's for lunch and what else are we growing?

Suggested range of plants in the original Space veggies solution could be diversified. In addition there are some problems especially with plants requiring long periods of time to mature and produce crops. It might be advisable to avoid cultivating them in the starting period of Mars colonizing or to restrict their cultivation to dedicated greenhouse blocks. Quickly growing and completely edible plants should constitute the core of cultivated plants. With this in mind it is of outmost importance that plants are not only grown for edible parts but also for seeds to ensure continuity of cultivation.

Fungiculture could be considered as a way of introducing diversity in to the diet as well as means of using composted plant waste. In addition to food, fuel production could be integrated not only to outer structures but into living spaces. Algae cultures could be grown in green walls in order to bring nature into everyday life.

Literature

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