Maryland Aquaponic Greenhouse Environment:

M.A.G.E.

An Entry in NASA's 2019 BIG Idea Challenge

Space Systems Lab

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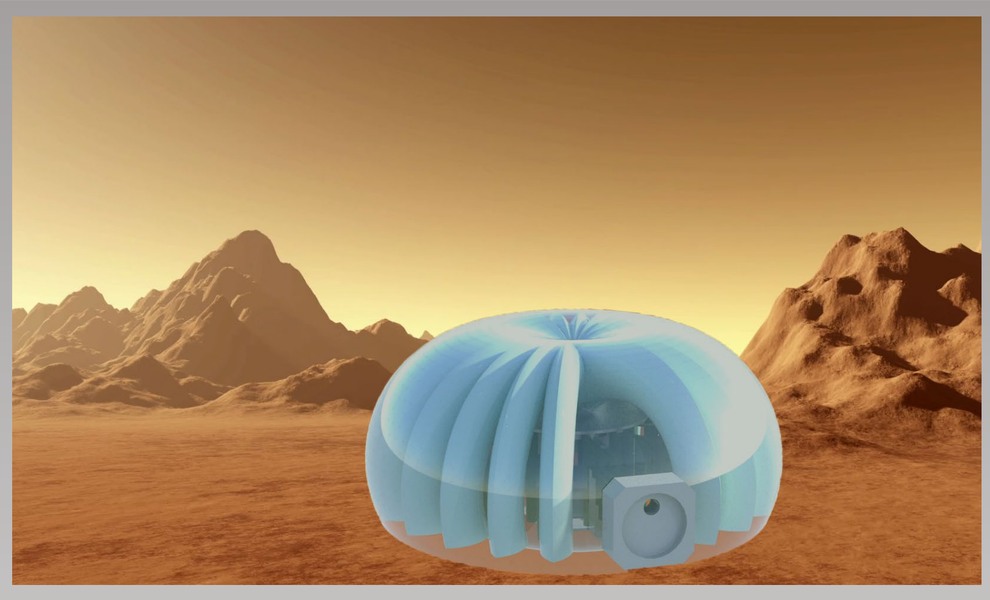
Objective:

Design an inflatable greenhouse to supplement food production on an extended surface mission to Mars. Utilize innovative ideas and make use of existing literature to aid in design. Create a ten page proposal and two minute video highlighting our design and con-ops to submit as part of NASA's 2019 BIG Idea Challenge.

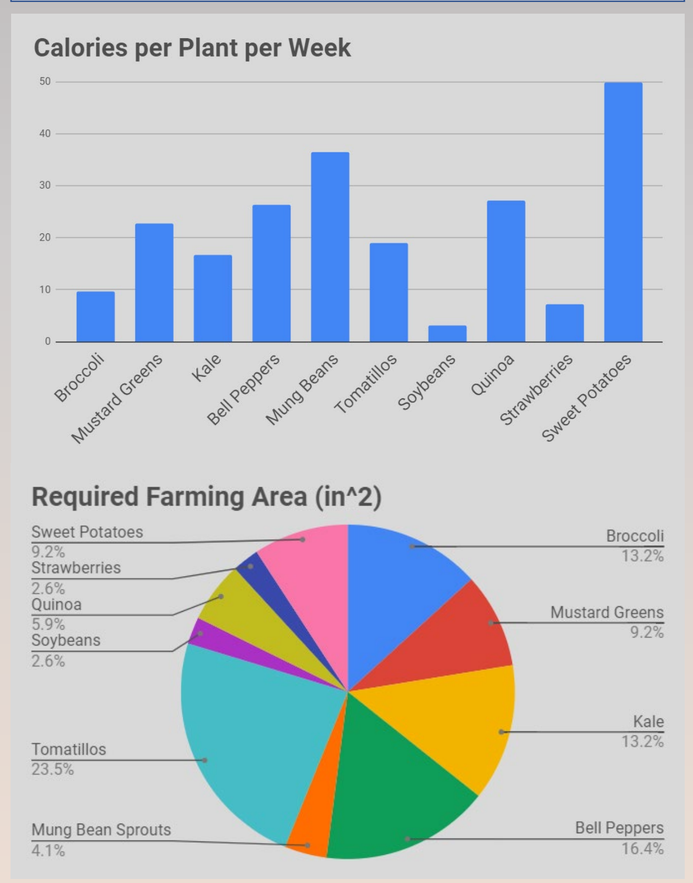


Design Guidelines and Considerations:

- Food production to support a crew of 4 for a 600 day surface mission
- Provide 50% or more of total nutritional requirements
- Utilize Ice Home proposal
- Launch mass of under 18,000 kg
- Consider systems approach

Research Overview:

The necessity of a sustainable means of food production to support human factors during a human mission to Mars must be addressed. Solutions regarding radiation protection and ample habitable volume have been established through NASA's Ice Home proposal. We propose the M.A.G.E. system, a highly innovative inflatable greenhouse that utilizes aquaponic systems, modular shelving units which flex and rotate for ease of access, and synergizes with previously developed technology found in the Ice Home and the International Space Station to produce optimal usage and yield.



Ten plants were chosen to be grown in the greenhouse. Above highlights research into the proportional area requirements for the plants and the caloric output for each individual plant per week. These plants were chosen for maximum nutritional output and diversity.

Figure 1

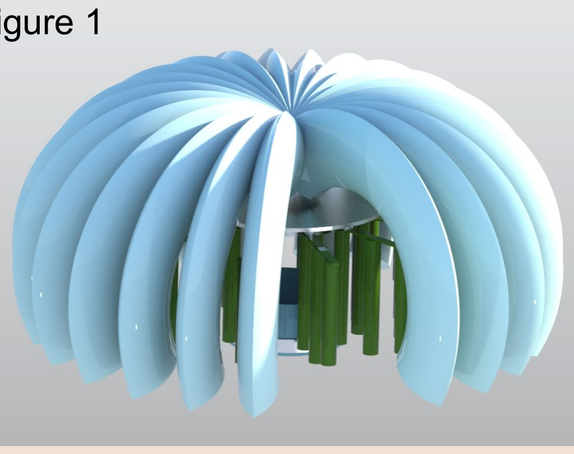
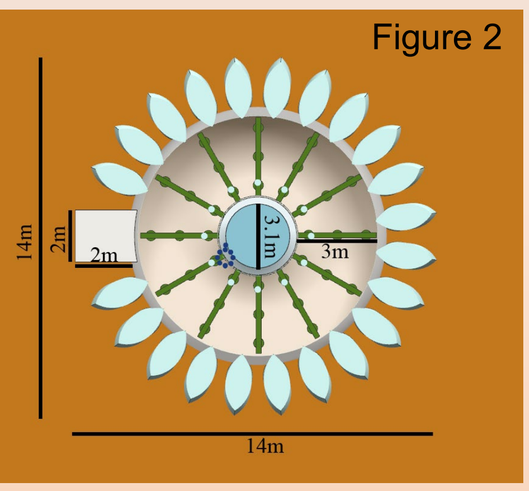


Figure 2

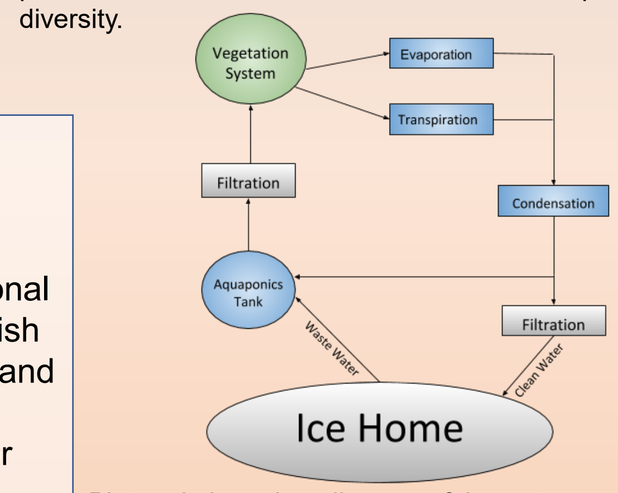


Sample Meal Plans	Variant 1	Variant 2	Variant 3
Breakfast	Quinoa porridge with sliced strawberries	Strawberry and kale smoothie	Sweet potato and kale breakfast hash
Lunch	Grilled tiliapia with tomatillo sauce and a side kale salad	Kale and mustard greens stuffed tilapia	Roasted broccoli quinoa salad with mung bean sprouts side dish
Dinner	Soybean and broccoli casserole and sauteed mustard greens	Quinoa and vegetable soup (using vegetable stock)	Tilapia burrito with tomatillo salsa, sliced peppers and soybean hummus

Listed above are a sample of possible meals that could be prepared using greenhouse produce. These can be rearranged to create over two weeks worth of unique meals. With the addition of supplemented food and more recipes, astronauts will receive a diverse variety of meals and nutrients.

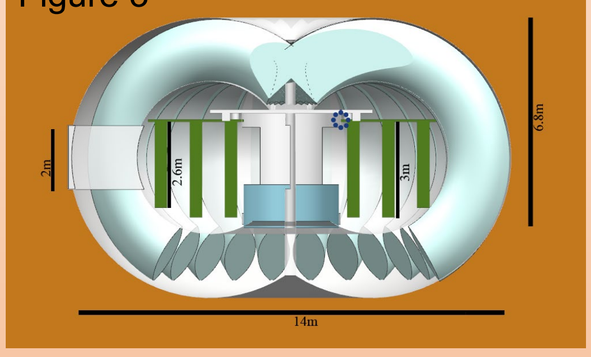
Methodology:

The M.A.G.E. team conducted a thorough literature review of the competition requirements, prior relevant research, and the Ice Home proposal to guide research. The organics subgroup performed nutritional and growth analysis to decide upon plants grown and what breed of fish to use. The systems subgroup researched different growing systems and methods to maximize output and minimize servicing requirements. Additionally, structures analyzed exterior inflatable shapes and interior greenhouse configurations to maximize growing area while allocating enough space for crew to service the greenhouse.



Pictured above is a diagram of the water resource flow throughout the greenhouse system, and its interaction with the NASA Ice Home design.

Figure 3



Above: Figure 1 shows a render of the greenhouse that highlights the ice-baffle structure and the plant columns inside. Figure 2 is a birds-eye view of the greenhouse with section cut through ceiling, and Figure 3 shows a cross-section of greenhouse through its center.

Results and Design Choices:

The exterior greenhouse draws inspiration from the Ice Home proposal in materials and structure to simplify manufacturing and servicing. It is a toroidal inflatable that incorporates radial ice baffles that provide radiation protection for life inside. Inside the greenhouse, a central cylinder houses a tilapia tank and necessary instruments for operations and servicing. By feeding the tilapia, most of the required nutrients for the plants are then input into the hydroponic system, which delivers the water to the 36 radial columns where plants are housed. The remaining required nutrients are supplemented through piping in the sump collection. The plants act as a natural filter in turn for the tilapia, completing the closed cycle. Plant columns are grouped in three on support arms which can flex in place for ease of access. The above design guidelines and considerations will be achieved through the M.A.G.E. design. The team will continue to conduct research as it prepares the proposal document and video for submission to NASA.

Special Thanks:

We would like to thank Dr. Akin, Briana O'Neal, Aileen Hentz, and the student researchers of the Space Systems Lab for their advice and guidance.

References:

Competition Requirements: http://bigidea.nianet.org/

Nutritional Requirements: health.gov/dietaryguidelines/2015/resources/2015-2020_Dietary_Guidelines.pdf