SpaceGAMBIT Project Registration Form

1. Project Title
SilSuit

2. Primary Contact
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3. Project Summary

This project is for the development of a prototype partial space suit that in the future, can be developed into a self-contained mechanical pressure suit for in-space extra-vehicular activity with integrated HUD (Heads-Up Display) for GUI (Graphical User Interface) for suit control and status. The aim is to improve current space suit designed by improving mobility, reducing bulk, space suit cost and manufacturing complexity by use of mechanical pressure and experimenting with different designs, materials and manufacturing techniques.

4. Relevance to SpaceGAMBIT Mission

This project will support the development of self-contained space suits for spaceflight by developing simple prototype partial suits to experiment with different technologies, materials and manufacturing methods and sharing the results. The results of the experiment supports maker education by providing them the knowledge of how to make a space suit. The suit's development will improve the near-space economy by providing a more cost-effective means to provide a human habitat in spaceflight as well as making available the knowledge and technology to develop space suits.. Reduced cost will provide more operating cost margin for the spaceflight industry and the shared knowledge will enable the public to develop suits of their own. By developing these developments and shared knowledge, humanity will know how to make a suit to wear while exploring space.

5. Project Description

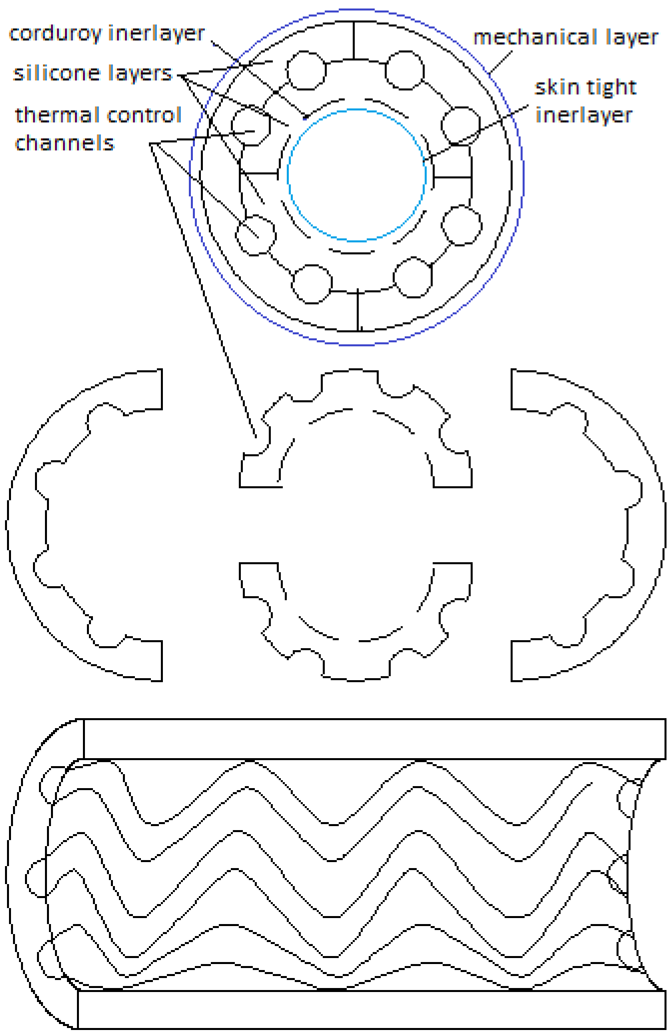
The base technology for the suit is the use of a nylon fabric wicking layer on the inside of a channeled silicone (or otherwise) shell. The channeling provides areas where fluid can circulate for thermal regulation. The outermost layer mechanically provides the pressure. It can either be a carbon fiber weave or a series of cables to hold the pressure.

The suit will be manufactured by taking a 3-D scan of the wearer's body. From that data, one can make a mold of their body from which the silicone layer can be molded to form the suit. CNC and 3-D printing technology can be used to build the mold.

The project is divided into several stages that will experiment with different designs, materials and manufacturing techniques to find the optimal in cost and effort to make a space suit.

1. Sleeve Development.
    a. Develop a sample part such as an arm sleeve to determine what designs, materials and manufacturing techniques work the best. The sample part will be tested for cost, manufacturability, comfort, mobility, functionality in a vacuum and thermally evaluated to determine heating/cooling capabilities to determine how much thermal protection is required.
2. Partial Suit Prototype
    a. From the results of the Sleeve Development, develop a partial suit prototype to test comfort, mobility and functionality (this will require the development of an appropriate vacuum chamber). This suit will rely on external life support.
3. FUTURE DEVELOPMENT (Beyond 4-Month Period) - Full Functioning Suit
    a. From the Full Suit Prototype, develop a fully-contained and fully-functional space suit with independent life support and appropriate thermal protection systems that can support a human for X hours working in a vacuum environment. Suit helmet will also have an integrated HUD. This suit is planned to be developed after the completion of this project to develop the Full Suit Prototype.

This project helps accelerate exploration as a space suit. By providing the knowledge of how one is designed, built and used, we will help other space endeavors sent people into space. Our suit is similar in working priciples to the MIT Biosuit (http://mvl.mit.edu/EVA/biosuit/). We work with a design integrating the gas containment and thermal regulation layers to reduce suit complexity and weight, ease manufacturing and allow functionality in vacuum environments.



6. Methods and Implementation Plan

This is the portion of the proposal where you'll clarify objectives, assign tasks with deadlines, and chart your progress in reaching goals and milestones.

a. Objectives

1. For Sleeve
   a. Develop a qualified design and manufacturing process.
2. For Partial Suit
   a. Qualify the selected design and manufacturing process from the sleeves for a more significant portion of the suit.

b. Tasks

a. For Sleeve
   i. Make molds of arm.
   ii. Cast silicone in molds.
   iii. Assemble sealed test article of inner nylon, middle silicone and outer

mechanical layers.

iv. Test functionality for pressure and thermal regulation and containment in a vacuum oven over a temperature range expected in a space environment in space vacuum.

v. Repeat process for different designs and manufacturing processes.

b. For Partial Suit

i. Downselect design and manufacturing process from Sleeve development and apply to larger test articles.

ii. Make molds of appropriate body parts.

iii. Cast silicone in molds.

iv. Assemble sealed test article of inner nylon, middle silicone and outer mechanical layers.

v. Test functionality for pressure and thermal regulation and containment in a vacuum oven over a temperature range expected in a space environment in space vacuum.

vi. Verify the functionality and integrity of the partial suit.

c. Time allocation

1. 1st Month
   a. Preparation work for the project, procurement of necessary material and gear.
2. 2nd and 3rd Month
   a. Development of Sleeve.
3. 4th Month
   a. Development of Partial Suit.

d. Milestones and Deadlines

1. Completion of Sleeve development and qualification. Deadline by 3rd Month.
2. Completion of Partial Suit development and qualification. Deadline by 4th Month.

7. Team, Hosting and Partner Organizations

- Principle Instigator - Robert McBrayer
  - Robert is currently working on his Masters in Space Studies and is passionate about space and working on technology to get humanity into space. He has a wide variety of interests from space and physics. He has a Bachelor's Degree in mathematics. He is an active member of Mojave Makers and has built many project ranging from Tesla coils to a CNC router. He also has experience working with silicone for special effects makeup. He will be managing and leading the project as well as doing engineering and technical work.
- Engineer & Bookkeeper - Ethan Chew
  - Ethan is an aerospace engineer who has worked in commercial space and has experience in composites manufacturing. He has experience taking prototype airplanes and rockets through the design-build-fly cycle and managing hackerspaces and hackerspace projects. He is a current board member of Mojave Makers and prior served on the board of Makers Local 256 in Huntsville,

AL. He also managed a near-space ballooning project at Makers Local 256. He will provide engineering and technical expertise to the project.

- Blogger - Doug Messier
  - Doug runs the space blog Parabolic Arc (parabolicarc.com), reporting on the latest news in Commercial Space. He has been a writer for 25 years and is well-versed at writing on technical and scientific subjects for the general public. Doug will write regular blog updates for the Mojave Makers website that will also be posted on Parabolic Arc, which averages about 26,000 unique visitors per month from all over the world. The dual exposure will provide this project, SpaceGAMBIT, and Mojave Makers a significant amount of media exposure.
- Host Organization - Mojave Makers
  - Mojave Makers started in Mojave, CA in April, 2012 near the technical and creative talent and energy of the commercial space industry at the Mojave Air & Space Port. The organization hosts entrepreneurs and hobbyists alike. Projects have ranged from unmanned aerial vehicles for surveillance, electric cars, 3-D printers and CNC machinery, permaculture gardens and rocket attitude control systems. The shop currently has hand tools and basic machine tools such as a drill press and table saws. Mojave Makers will support the project by providing a workspace. SpaceGAMBIT can support the project and Mojave Makers by providing fund support for tools and operations.

8. Budget

- $1,000 for vacuum ovens and pumps.
  - $875 for Napco 5831 Vacuum Oven, http://tinyurl.com/by5q6vb
  - $125 for FJC Inc. 6909 Two Stage Vacuum Pump - 3.0cfm, http://tinyurl.com/ak79s5c
- $500 for Composite Manufacturing Equipment, http://www.cstsales.com
- $1,000 for telemetry, instrumentation and sensors.
- $7,000 for materials.
  - $2,800 for Silicone Resin & Hardener of different varieties for experimentation, http://www.smooth-on.com
  - $200 for Nylon Fabric, http://www.cstsales.com
  - $500 for Fiberglass, http://www.cstsales.com
  - $2,000 for Carbon Fiber, http://www.cstsales.com
  - $1,000 for Resins, http://www.cstsales.com
- $6,900 for Labor*
- $1,000 for Safety Equipment
- $200 for Media
- $2,400 for Miscellaneous
- Total $20,000

*The labor payments are computed on 4-hour workdays paid at California minimum wage of $8/hr for 5 days per week over the 4-month duration of the project plus $1,250 for the blogger commission fees.

9. Project Deliverables

1. Sleeve Development. Expected delivery at end of 3rd Month.
    a. This prototype part will serve as a proof-of-concept deliverable that will verify the functionality and manufacturability of our design as well as provide information to the open-source community on how the product was developed and made.
2. Partial Suit Prototype. Expected delivery at end of 4th Month.
    a. This prototype will be a functional partial suit that depends on external life support. The information from its design, development and manufacture can be delivered as open-source material.
3. Project Report. Expected delivery at end of 4th Month.
    a. Full project report including summary, detailed project report describing project, design, engineering and build decisions, rationales and processes, accounting reports and a final blog post summarizing project.