BACKGROUND
Exploration campaigns such as Mars sortie require an absence from Earth of over two years without logistical support to provide replacement parts. If several spares are launched for each critical Line Replaceable Unit, launch mass is considerably increased, perhaps by a multiplier of four. If sparing is at the card level, up-mass could be reduced to a factor of 2.5 times. If sparing were at the component level, up-mass could be 1.5 times spacecraft weight. If a spacecraft can be 3D-printed and so materials sparing is possible, sparing might only add 5% to launch mass.

The International Space Station presently is experimenting with a 3D printer, using Ultem plastic filament. On the path to achieving 3D printed spacecraft, printed features with electrical physical properties are needed. While highly conductive Ultem PEI filament printer stock is not presently commercially available, several conductive PLA materials are readily available. Infused with graphite, graphene, or carbon nanotube composite materials, these have a variety of conductivities.

PROJECT/CHALLENGE
Conductive PLA’s produce lower conductivity along the z-axis of the print. This project should explore how significant the effect is for radio waves, and whether anything can be done about it. For example, annealing the plastic after printing might reduce the effect of solidification between printing of layers. Orientation of the honeycomb might also have a polarizing effect; honeycomb is always oriented along the z-axis, possibly exacerbating polarizing performance difference caused by the z-axis solidification effect if both effects increase impedance along that same axis. The project could consider whether there are interesting uses for a radio polarizer.

RF absorbers can be more effective than reflective RF shielding for containment of unwanted emissions and rejection of interference. The objective of this project is to 3D print and characterize, compared to models, either a plastic case for electronic equipment or an RF antenna hat coupler, using conventional printers and inexpensive filament. Observations of thermal conductivity could also suggest applications for sinking heat from hot spots (electronics processors and amplifiers) to cold spots. This project can experiment with several conductive plastic filament materials and infill patterns, wall thickness, or other printer settings. The project should evaluate printability of the materials. The project should characterize performance in terms of RF absorption across the spectrum, for example by encasing a broadband antenna.

REFERENCES
http://www.economist.com/node/21559593
http://www.airspacemag.com/space/printed-in-space-31911779/
https://www.nasa.gov/mission_pages/station/research/experiments/1115.html
https://www.youtube.com/watch?v=7clm8r4YnZI
http://www.blackmagic3d.com/Conductive-p/grphn-pla.htm
https://www.proto-pasta.com/products/conductive-pla
http://functionalize.com/product/1-pound-of-f-electric-filament-1-75mm-diameter/
http://www.boedeker.com/tempal_p.htm (conductive PEI, but isn't printer stock)

DELIVERABLES
Test article, report
<table>
<thead>
<tr>
<th>NASA MENTOR</th>
<th>Chatwin Lansdowne</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVEL</td>
<td>Upper Division Students [JR/SR]</td>
</tr>
<tr>
<td>MAJOR / DISCIPLINES</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>TEAMS</td>
<td>One team</td>
</tr>
<tr>
<td>DURATION</td>
<td>One-Semester Project</td>
</tr>
</tbody>
</table>