# SPS-ALPHA – IUPUI JAGS


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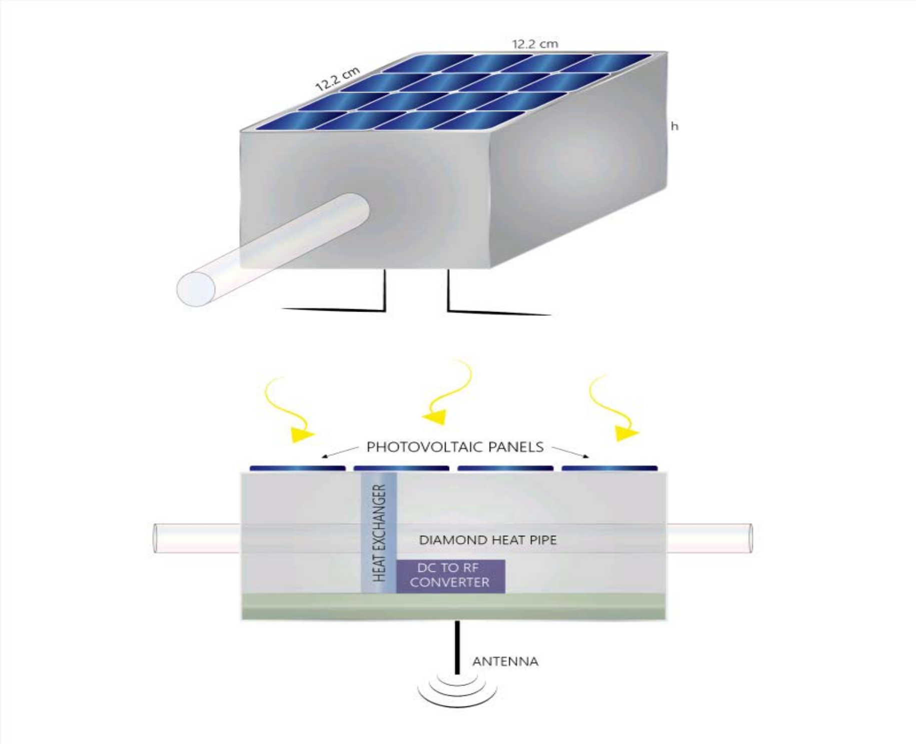
# THERMAL MANAGEMENT

- Heat tend to deteriorate electronic components
- Structural design consists of a diamond heat pipe
- Accumulated heat will be dissipated by the pipe through conduction



# DATA FOR THERMAL ANALYSIS:

- 1 Sun = 1350 $W/m^2$
- $Efficiency\ of\ photovoltaics\ panels$ = 25%
- $Maximum\ Operating\ Temperature\ of\ Silicon\ Components$ = 398.15 $K$
- $Area\ of$ Sandwich M$odule$ = 0.0148 $m^2$
- $Efficiency\ of$ DC to RF Converter = 80%


Courtesy of: Dr. Paul Jaffe

# THERMAL CONDUCTIVITY CALCULATIONS:

Energy Concentration in GEO:

$$1350\frac{W}{m^2} * 3\ sun = 4050\ W/m^2$$

Energy Concentration per Module:

$$4050\frac{W}{m^2} * A_{SM} = 60.28\ \text{J/s}$$

- THE AMOUNT OF ENERGY CONCENTRATED PER MODULE IS ABOUT 60 W!
- 75% OF THAT ENERGY WILL BECOME HEAT.

Heat Transfer from Solar Panels: → $\dot{Q_{sp}} = 60.28\frac{J}{s} * (1 - 0.25) = 45\ J/s$

Heat Transfer from DC-RF Electronics: → $\dot{Q_{elec}} = 60.28\frac{J}{s} * 0.25 = 15.07 * (1 - 0.80) = 3\ J/s$

Total Heat Transfer:

$$\dot{Q} = \dot{Q_{sp}} + \dot{Q_{elec}} = \mathbf{48\ J/s}$$

- OUT OF THE 60W OF ENERGY CONCENTRATED IN ONE MODULE, 48W BECOME HEAT

- The only way to get rid of heat in space is through black body radiation.

Stefan-Boltzmann Law:

$$\dot{Q} = \varepsilon\theta A T^4$$

$$A = \frac{\dot{Q}}{\varepsilon\theta T^4}$$

$$* \, T_2 \text{ is assummed to be zero since temperature in space is negligible}$$

$$A = \frac{48\frac{J}{S}}{1 * \left(5.67 * 10^{-8}\frac{W}{m^2K^4}\right) * (T_1^4)}$$

Area Using Silicon: →

$$A_1 = \frac{48\frac{J}{S}}{1 * \left(5.67 * 10^{-8}\frac{W}{m^2K^4}\right) * (398.15K)^4}$$

$$\mathbf{A_1 = 0.033688\, m^2}$$

- Area needed to dissipate heat per module:

*Net Area:*

$$A_{net} = A_1 - A_{SM}$$

$$A_{net} = 0.0337\ m^2 - 0.0148\ m^2$$

$$A_{net} = 0.0189\ m^2$$

- Next questions is: How many modules?

Number of Modules in Transmitting Antenna

$$\# \, of \, modules = \frac{A_{transmitting \, antenna}}{A_{SM}}$$

$$\# \, of \, modules = \frac{\pi * R^2}{0.0148 \, m^2}$$

$$\# \, of \, modules = 47.89 * 10^6$$

- Transmitting antenna is composed of approximately 47.9 million modules.

Total Area:

$$A_{total} = \# \, of \, modules \, * \, A_{needed}$$

$$A_{total} = 47.89 * 10^6 * 0.0189 \, m^2$$

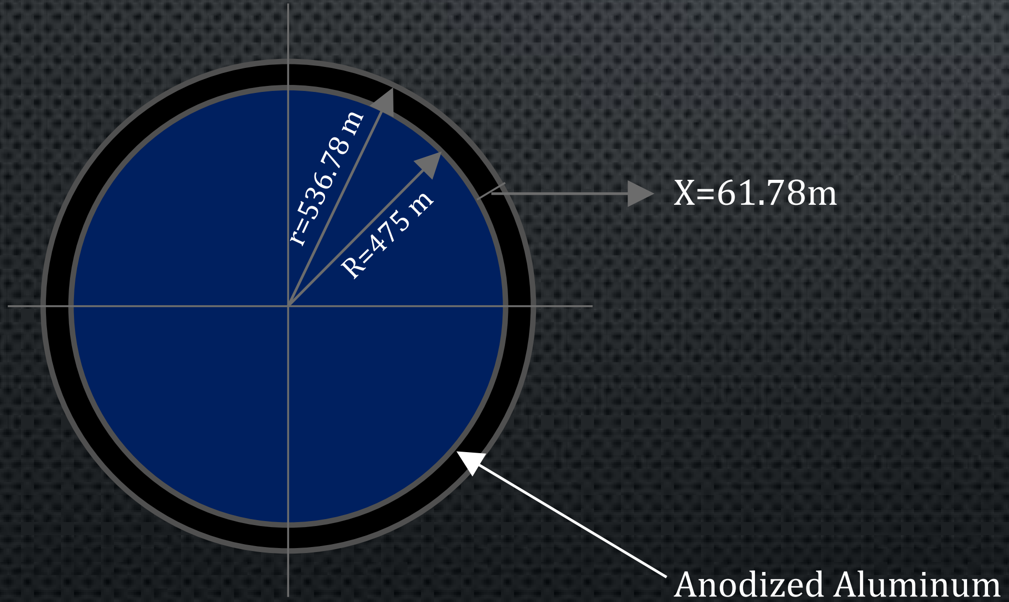
$$\boldsymbol{A_{total} = 905185 \, m^2}$$

$$A_{total} = \pi * r^2$$

$$r^2 = \frac{A_{total}}{\pi}$$

$$r^2 = \left(\frac{905185m^2}{\pi}\right)$$

$$r = 536.78\ m$$




Top View of Transmitting Antenna

- AN ADDITIONAL ANNULAR AREA OF APPROXIMATELY 200,000 M$^2$ WILL BE ADDED TO THE CURRENT DESIGN

# Assumptions:

- Diamond is a 'perfect' heat conductor
- Individual modules are rectangular prism shaped

# HOW TO OBTAIN DIAMONDS

- Carbonaceous Chondrite
- Atomic Layer Decomposition (ALD)

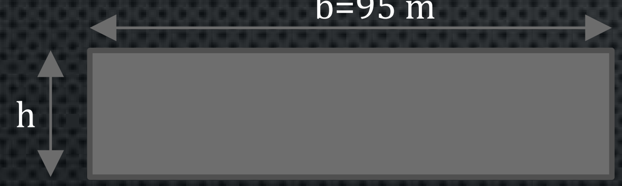
# STIFFNESS ANALYSIS

Load per Unit Length

$$*\,\omega = \frac{1 * 10^{-6} * m * g}{L}$$

$$*\,\omega = \frac{1 * 10^{-6} * 9.8\left(\frac{m}{s}\right) * (475\ m * 95\ m * h) * \left(1000\,\frac{kg}{m^3}\right)}{475\ m}$$

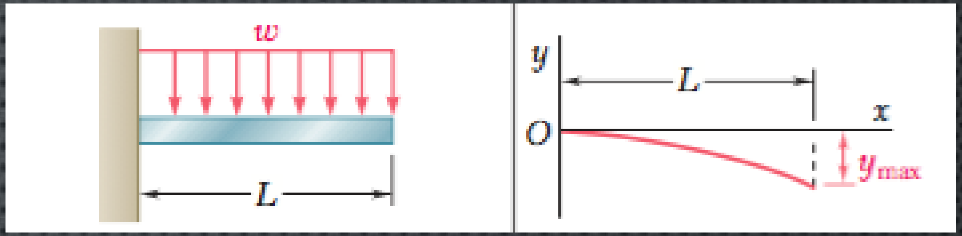
$$*\,\omega = 0.93195 * h$$




Moment of Inertia about the X-Axis

$$I_X = \frac{b * h^3}{12}$$

$$I_x = 7.916 * h^3$$




Courtesy of: Mechanics of Materials 7th Ed.

$$\delta_{MAX} = \frac{\omega * L^4}{8 * E * I}$$

$$0.0122m < \frac{(0.03195 * h) * (475m)^4}{8 * (1220 * 10^9) * (7.916 * h^3)}$$

$$0.0122m < \frac{4.744 * 10^{10}}{7.726 * 10^{13} * h^2}$$

$$9.4257 * h^2 > 4.744 * 10^{10}$$

$$h > 0.22435m$$

# Conclusion

- Highly efficient thermal design
- Rigid structure to support forces in GEO.
- Assumptions merit further inspection

# Thank you for your Attention!

# REFERENCES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