

Fox-1

Thermal Design

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Fox-1 Thermal Design

- **Objective – Create a thermal environment that will enhance the performance of the electronic payload.**
- **Provide proof of engineering design through the use of long proven thermal analytic methods and software.**

Fox-1 Thermal Design

- **Goals:**

**Compatible Electronic Temperatures to
Enhance Reliable Performance in Space**

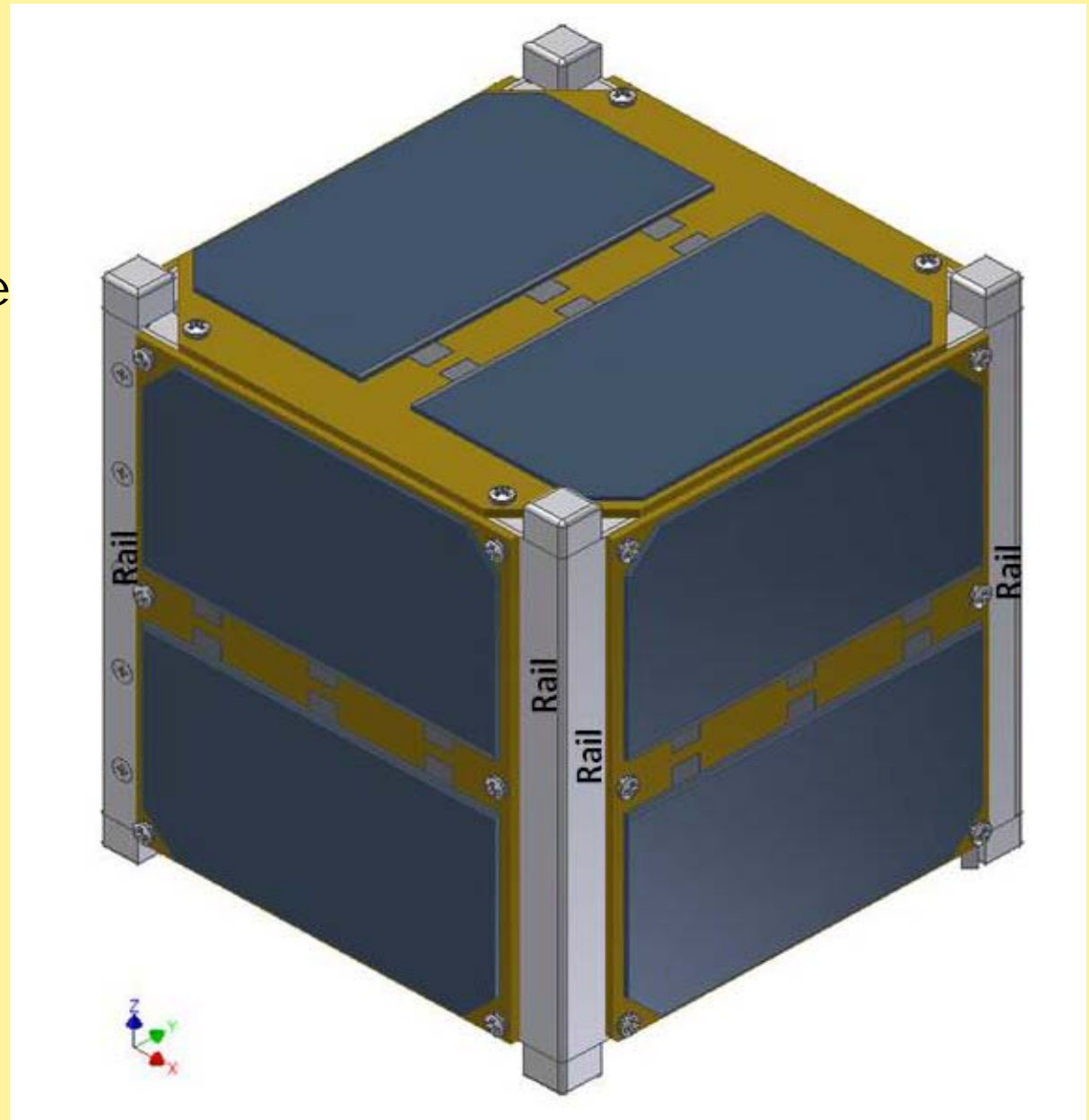
- **Methods:**

1. **External Thermal Coatings
(Not Possible in Fox Cubesat Design)**

2. **Internal Control Methods**

Fox-1 External View w/o Antennas

No Area Available
for Thermal
Coatings As All
Surface Features
Have Been
"Spoken For"!
No Coatings,
No MLI



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- **Heat Sources:**

1. **Sun – $\approx 5500\text{K}$ ($9,400^\circ\text{F}$) Radiant Heat Source**
2. **Earth Albedo – Reflected Solar Energy**
3. **Earth Planetary – IR Heating
From 290K (62°F) Sphere**
4. **PCB Dissipation**

- **Heat Sink:**

IR Radiation to 4K (-452°F) 4π Steradian Space

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- **Analytic Tools:**
 1. **NEVADA Monte-Carlo Radiation Analysis:**
RENO for Radiant Interchange (Internal)
VEGAS for External Heating
 2. **SINDA/G Thermal Analyzer**
 3. **Excel Spread Sheets for Data Analysis**

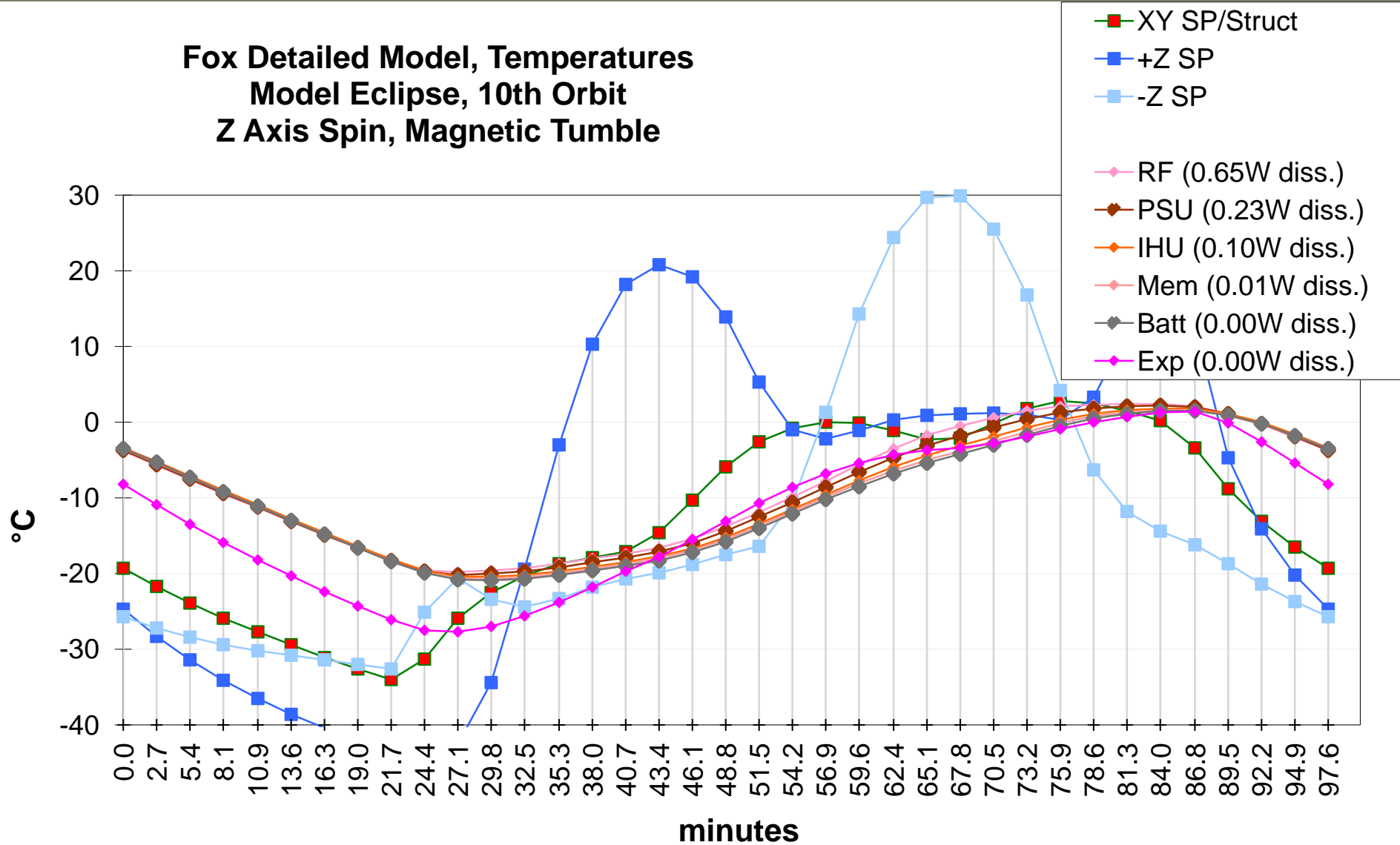
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- **Specification temperatures range from -40°C to +50°C, far too wide for good electronic design practice with OTC components.**
- **Original Analyses Showed Undesirable Electronic Temperatures of +3°C down to -20°C. The PCBs Had a Small Degree of Thermal Isolation, But Not Nearly Enough.**

Fox-1 Temperatures

PCBs Mounted Directly to Spaceframe

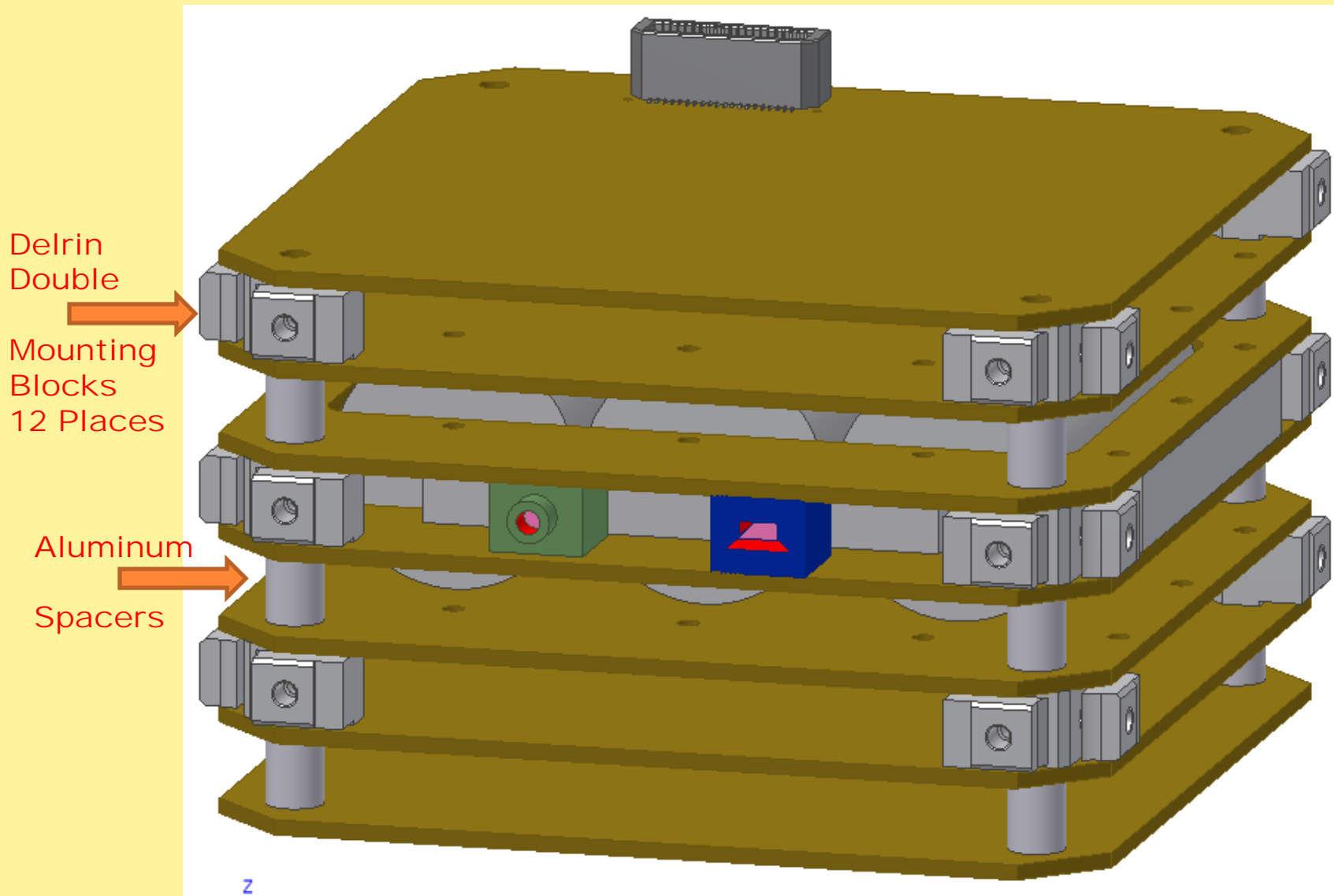
Fox Detailed Model, Temperatures
Model Eclipse, 10th Orbit
Z Axis Spin, Magnetic Tumble



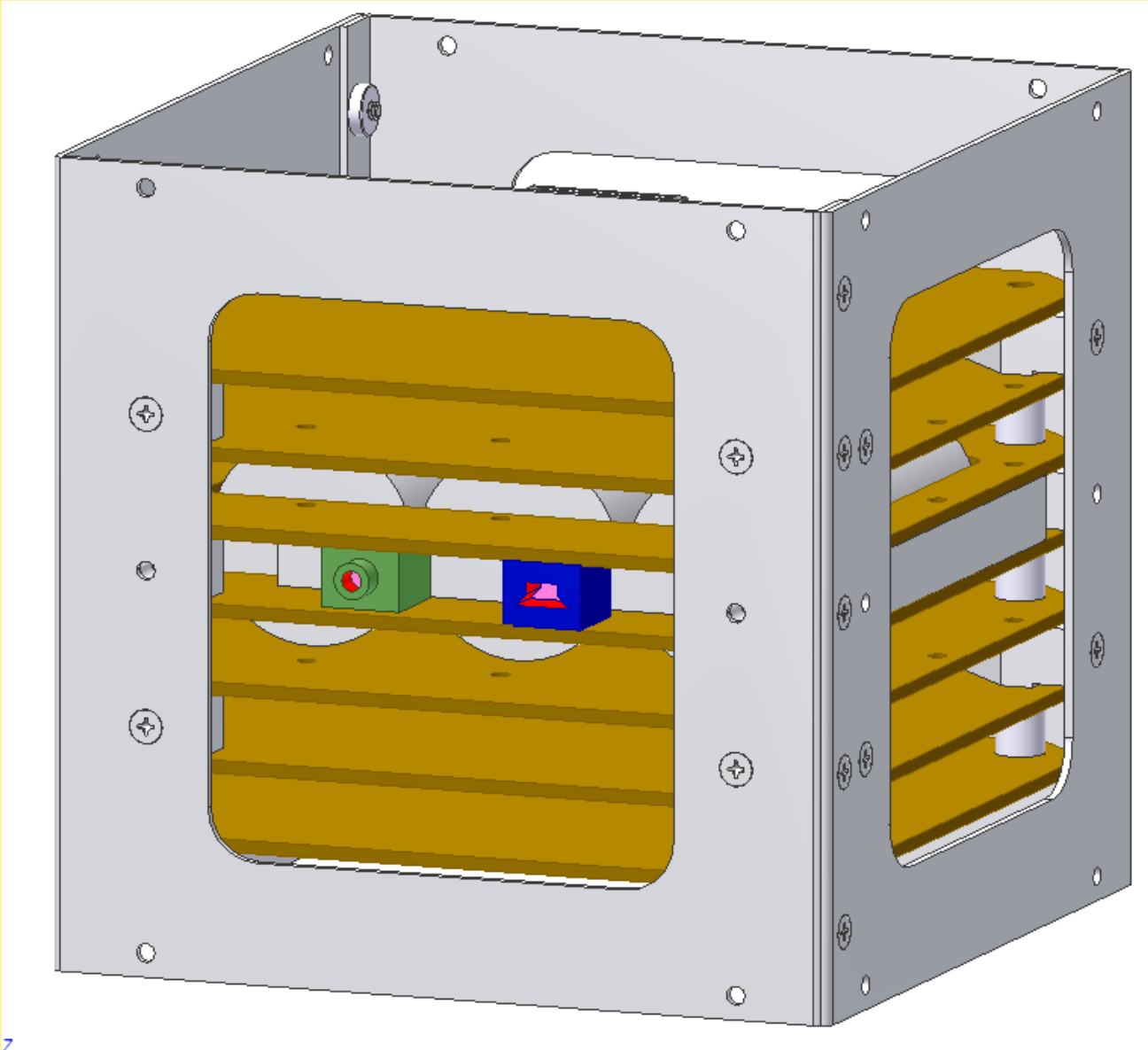
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- **Solution:**
 1. **Enhance PCB Thermal Isolation As a Stack Assembly of PCBs**
 2. **Encourage PCB Dissipations to Provide Self-Heating of PCB Stack**

Fox-1 PCB Stack – Basic Configuration



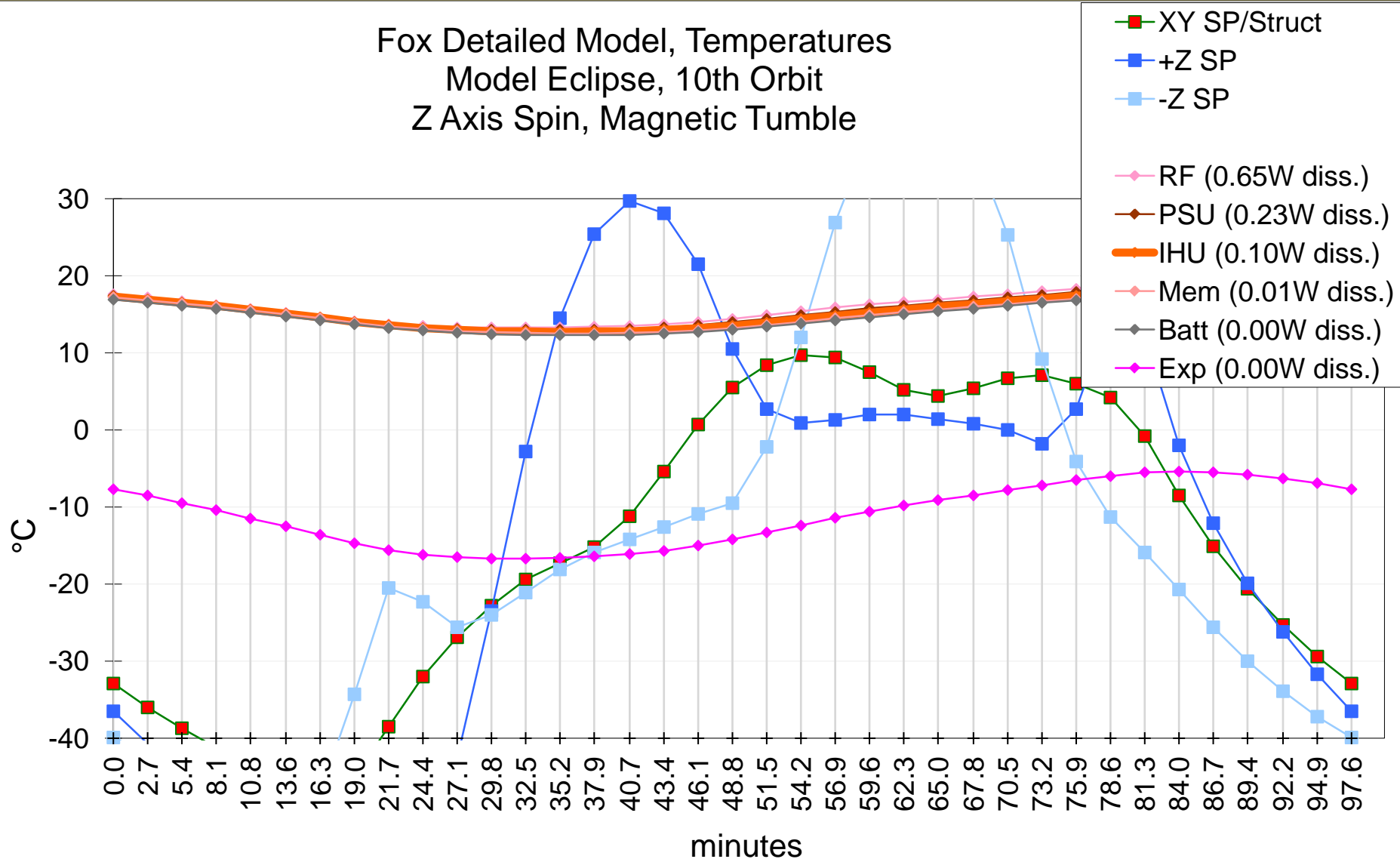
Fox-1 PCB Stack Mounted in S/C



Fox 1 Temperatures Maximum Eclipse

PCBs In Thermally Isolated Stack

Fox Detailed Model, Temperatures
 Model Eclipse, 10th Orbit
 Z Axis Spin, Magnetic Tumble

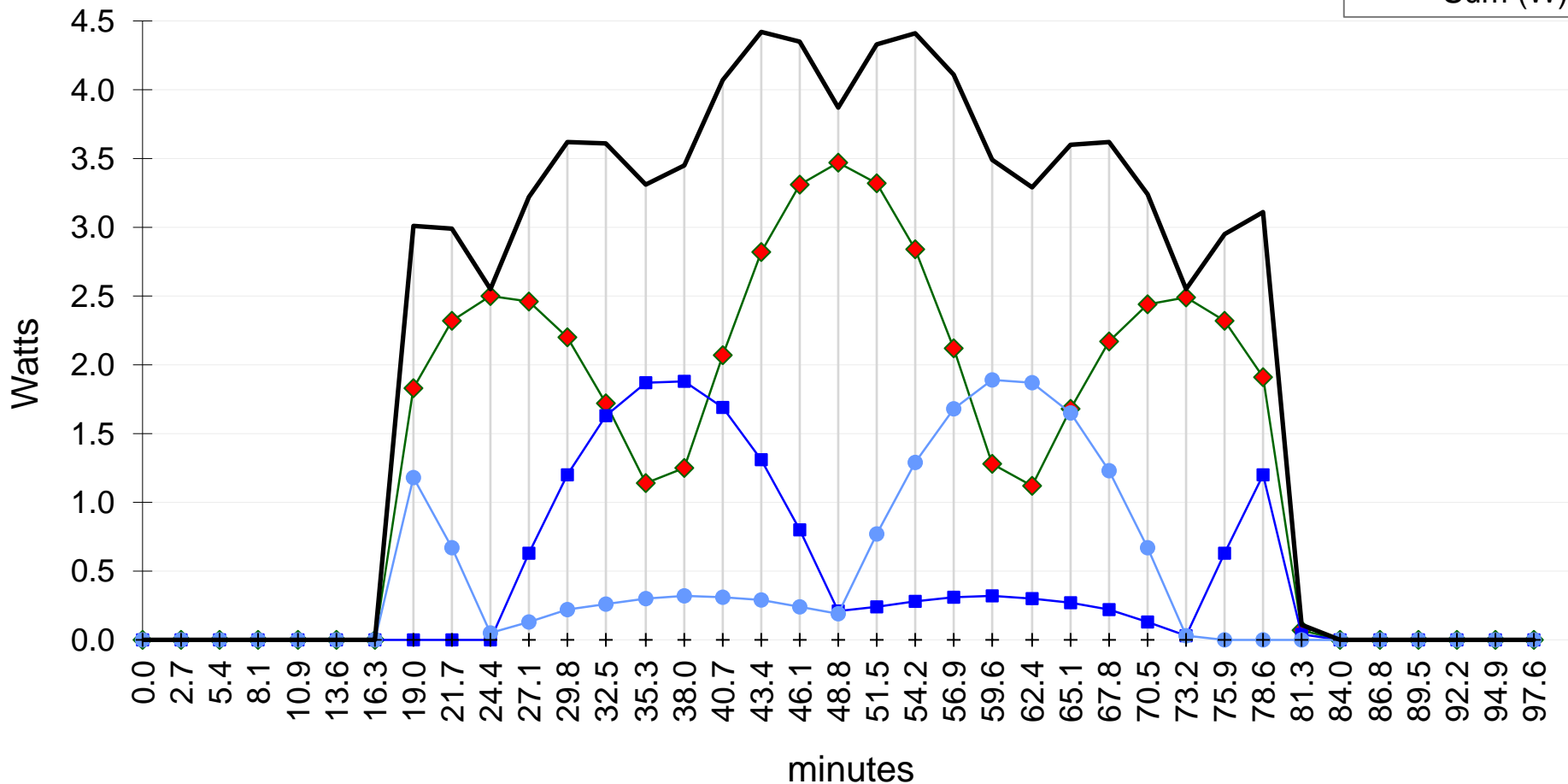


Fox-1 Power Generation Maximum Eclipse

Showing Complex Spacecraft Motions

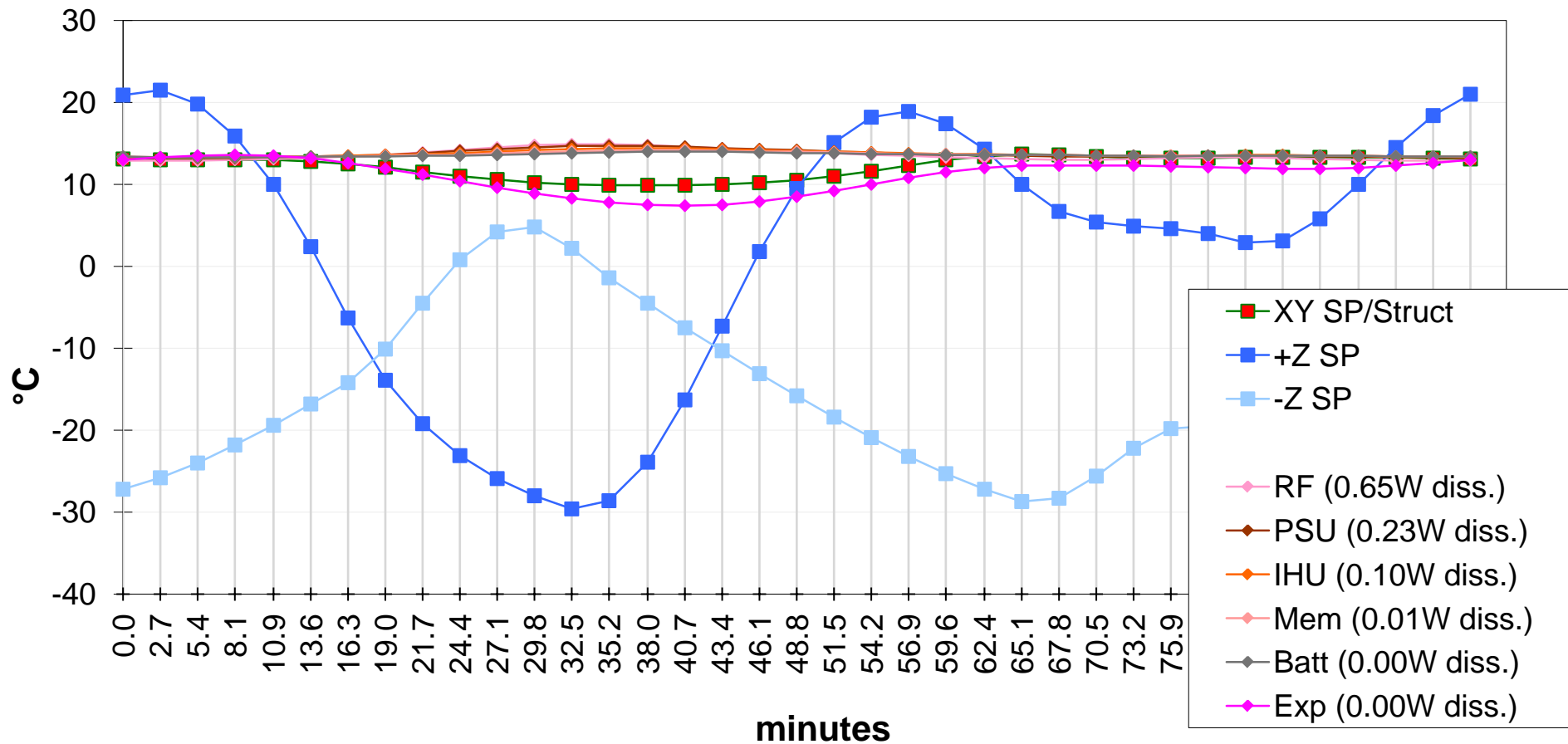
Fox Detailed Model, Solar+Albedo Power
Model Eclipse, 10th Orbit
Z Axis Spin, Magnetic Tumble

- X-Y (W)
- +Z (W)
- Z (W)
- Sum (W)



Fox-1 Temperatures Full Sun Orbit PCBs In Thermally Isolated Stack

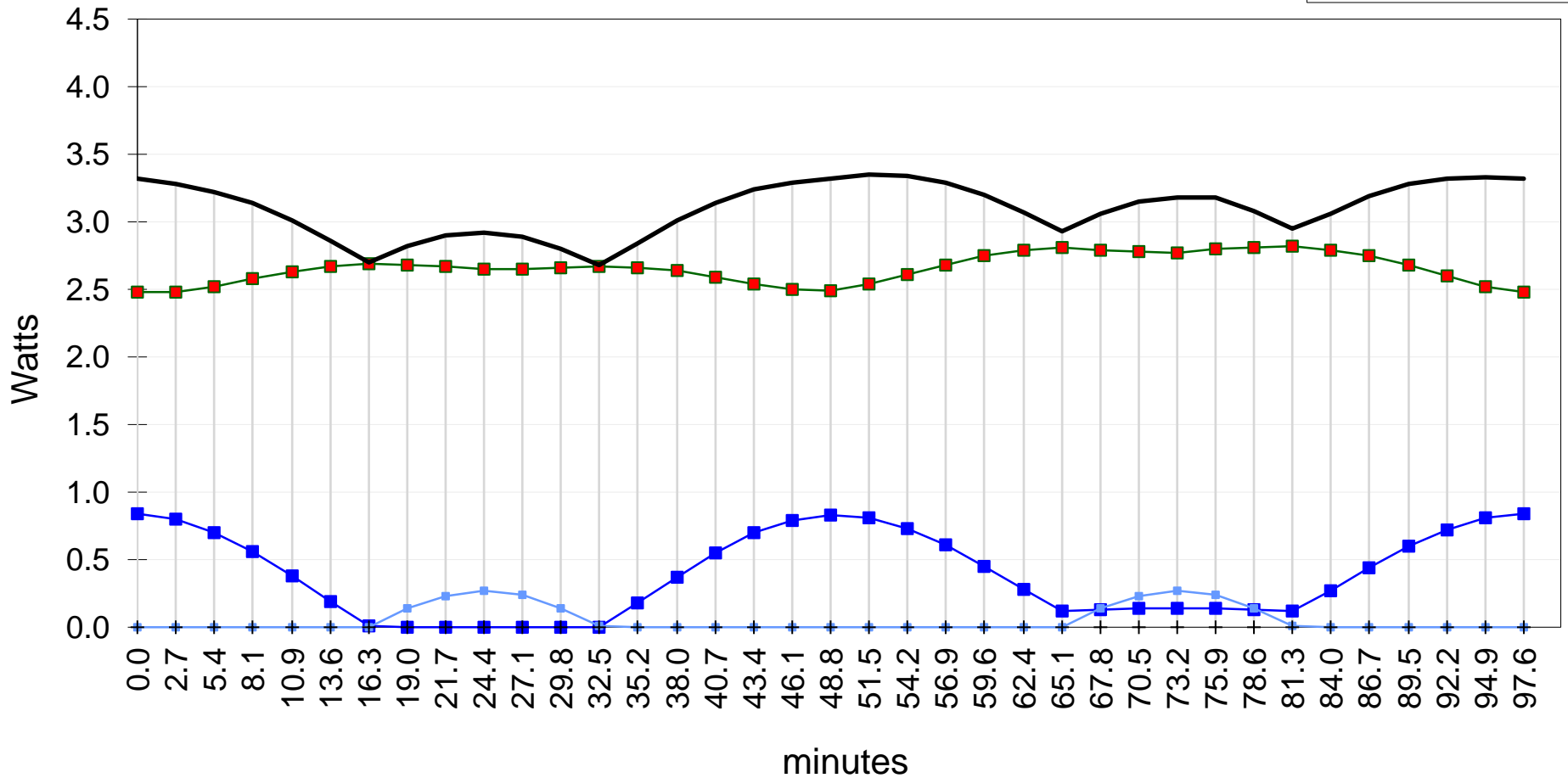
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Fox-1 Power Generation Full Sun Orbit

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- X-Y (W)
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Fox-1 Thermal Design

- **Studies to date indicate that a benign thermal environment for the electronic components and assemblies can be achieved.**
- **Clearly, however, these forecasts need to be confirmed with more study and testing.**
- **These studies and designs are fully applicable for a future Fox-2 CubeSat with deployable solar panels.**