PocketRTG – a CubeSat scale radioisotope thermoelectric generator using COTS fuel.

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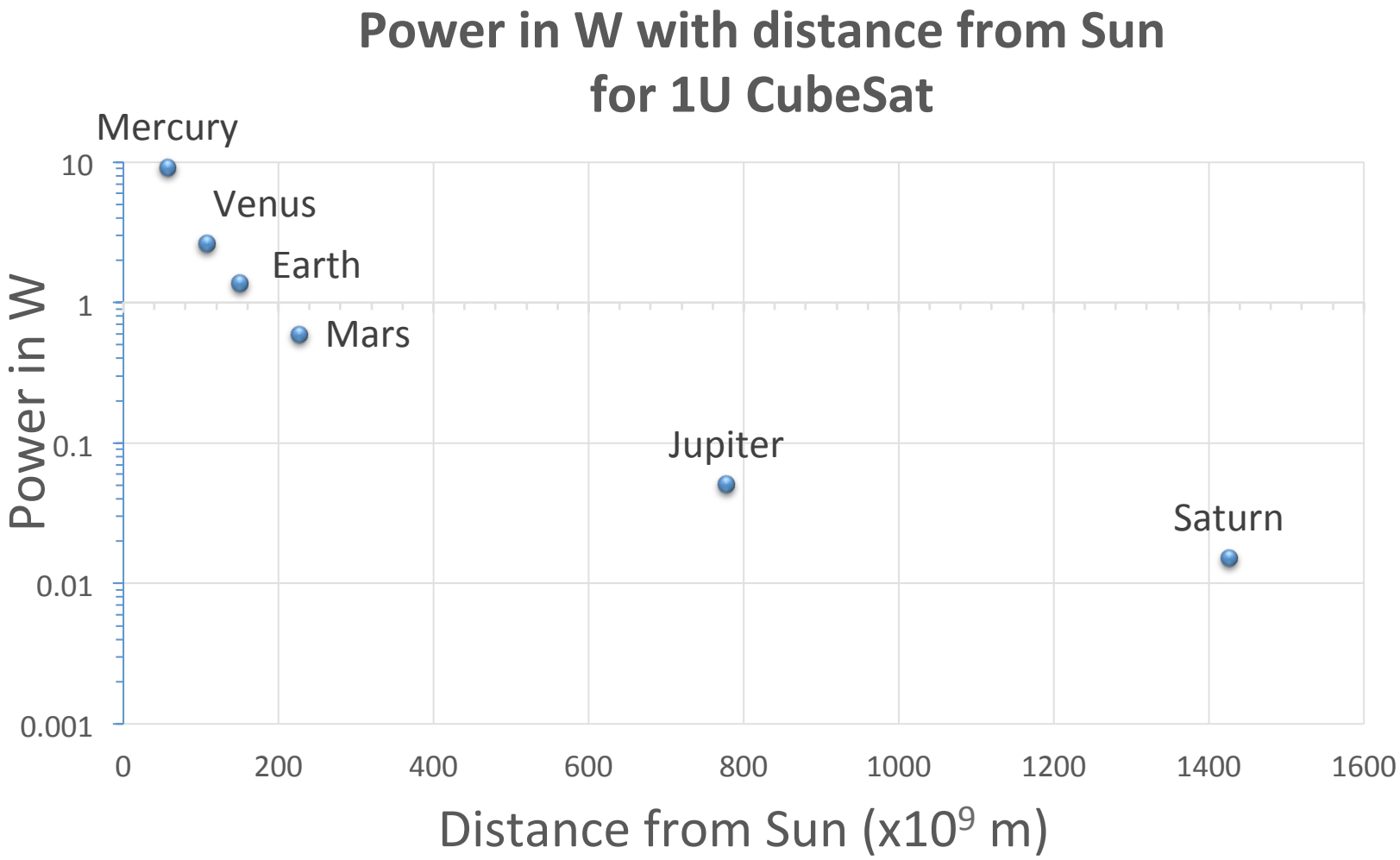
1. Why RTGs?

- Currently interplanetary CubeSat capability is limited by power.
- Solar power density falls off as $1/\text{distance}^2$


Power in W with distance from Sun for 1U CubeSat
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Power in W
10
1
0.1
0.01
0.001
0
200
400
600
800
1000
1200
1400
1600
Distance from Sun (x10^9 m)

Pacemaker background

Pacemakers used Pu-238 until 1980's when Li-Ion took over.

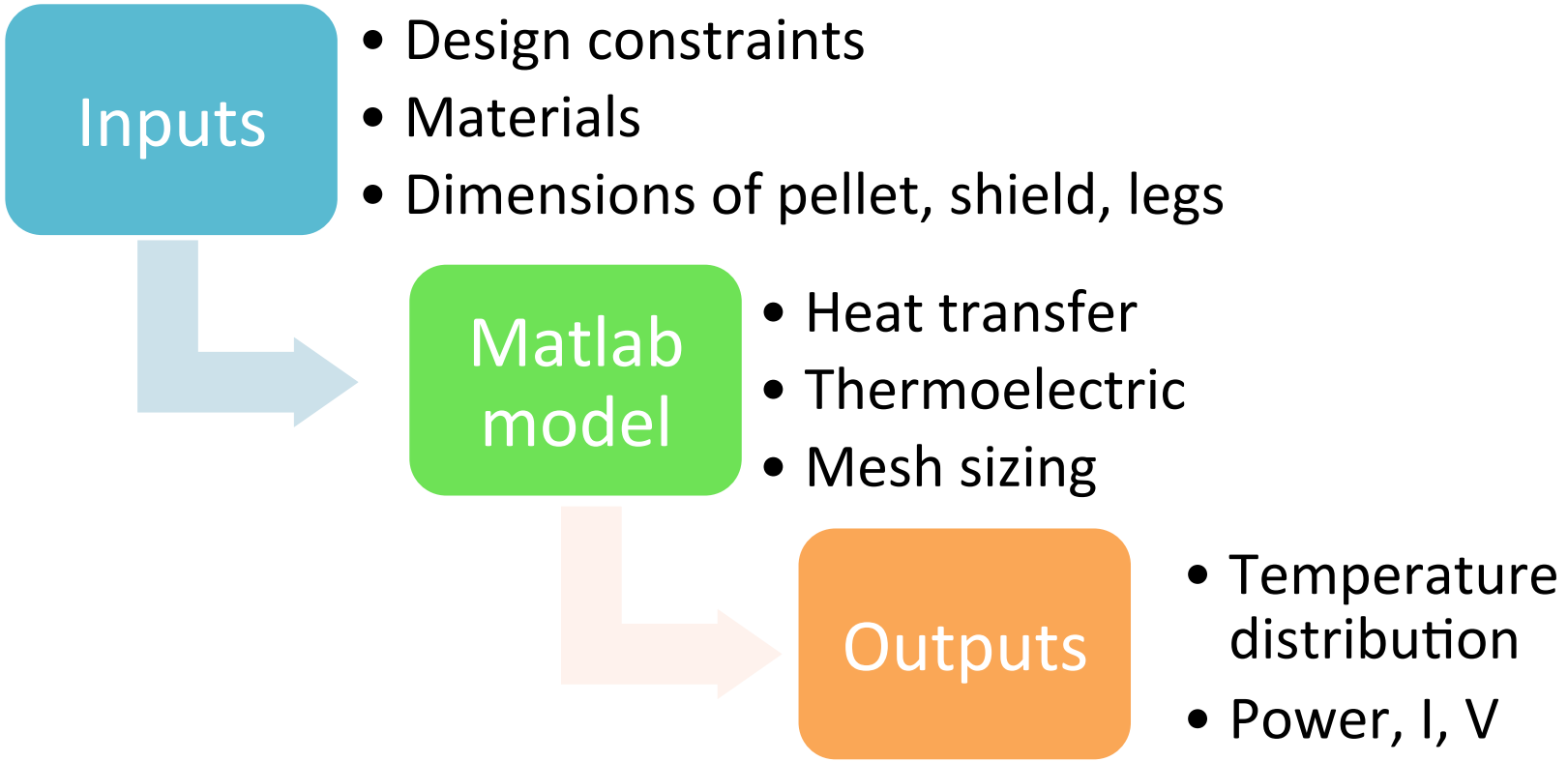
Adapting principles would make interplanetary CubeSat travel more accessible.

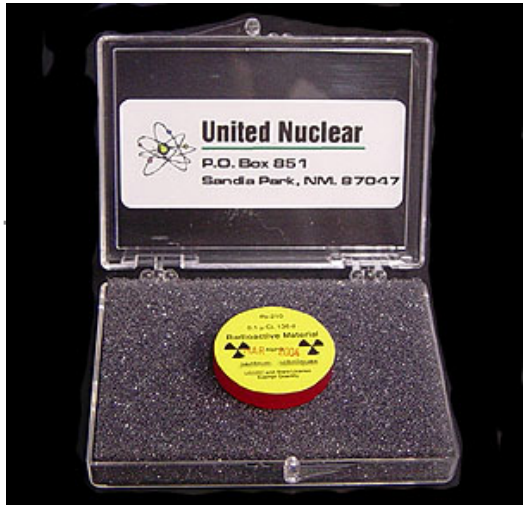
Medtronic plutonium-powered Pacemaker, 1974 (Pu removed)

2. Constraints for design

- Pu-238 not available, COTS alternative required
- Size limited to 5cmx10cmx10cm
- Mass limited to 0.66kg
- Temperature at face: 90°C
- Radiation shielding
- Safety encapsulation

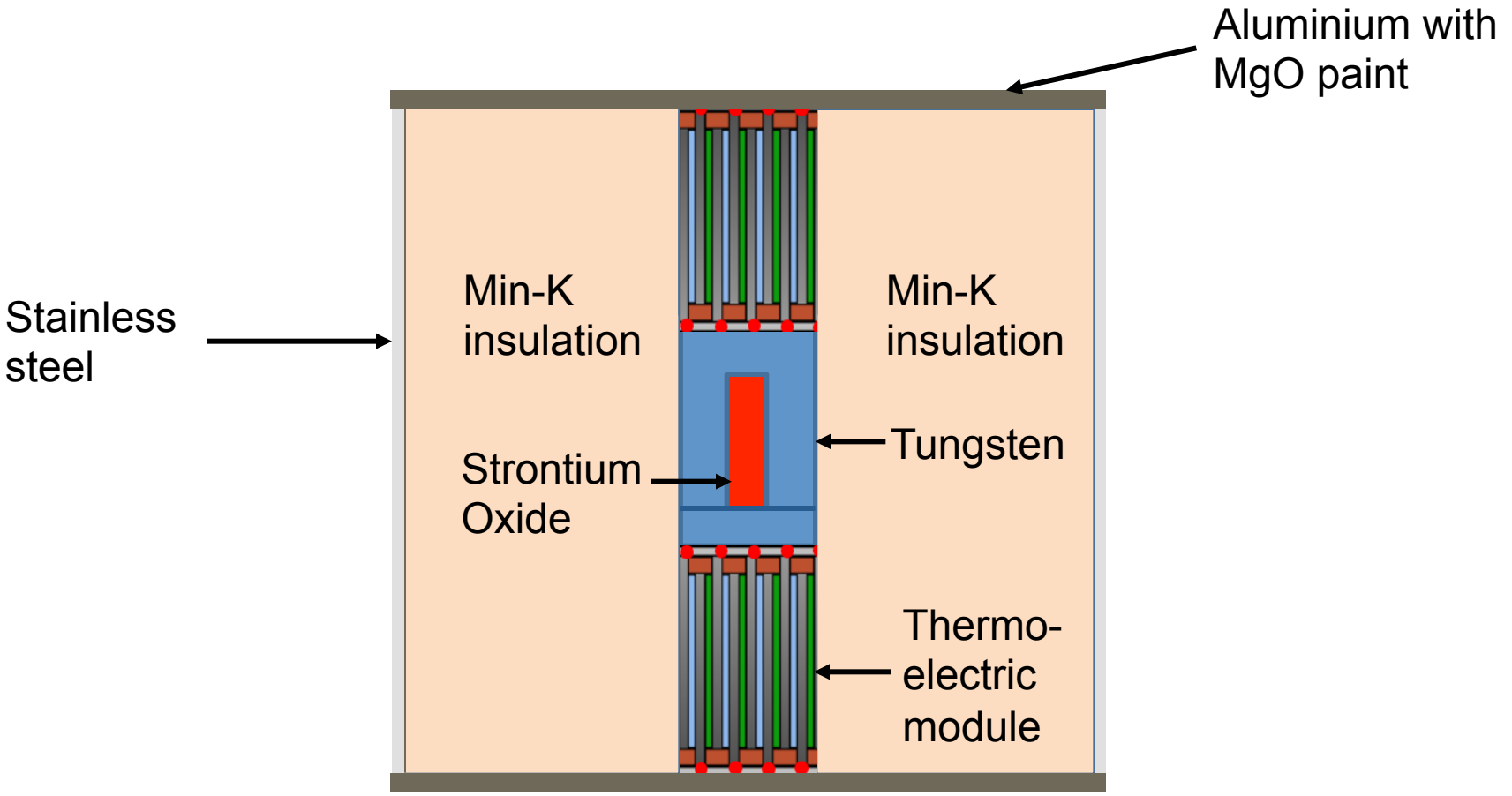
Model


Inputs
Design constraints
Materials
Dimensions of pellet, shield, legs
Matlab model
Heat transfer
Thermoelectric
Mesh sizing
Outputs
Temperature distribution
Power, I, V



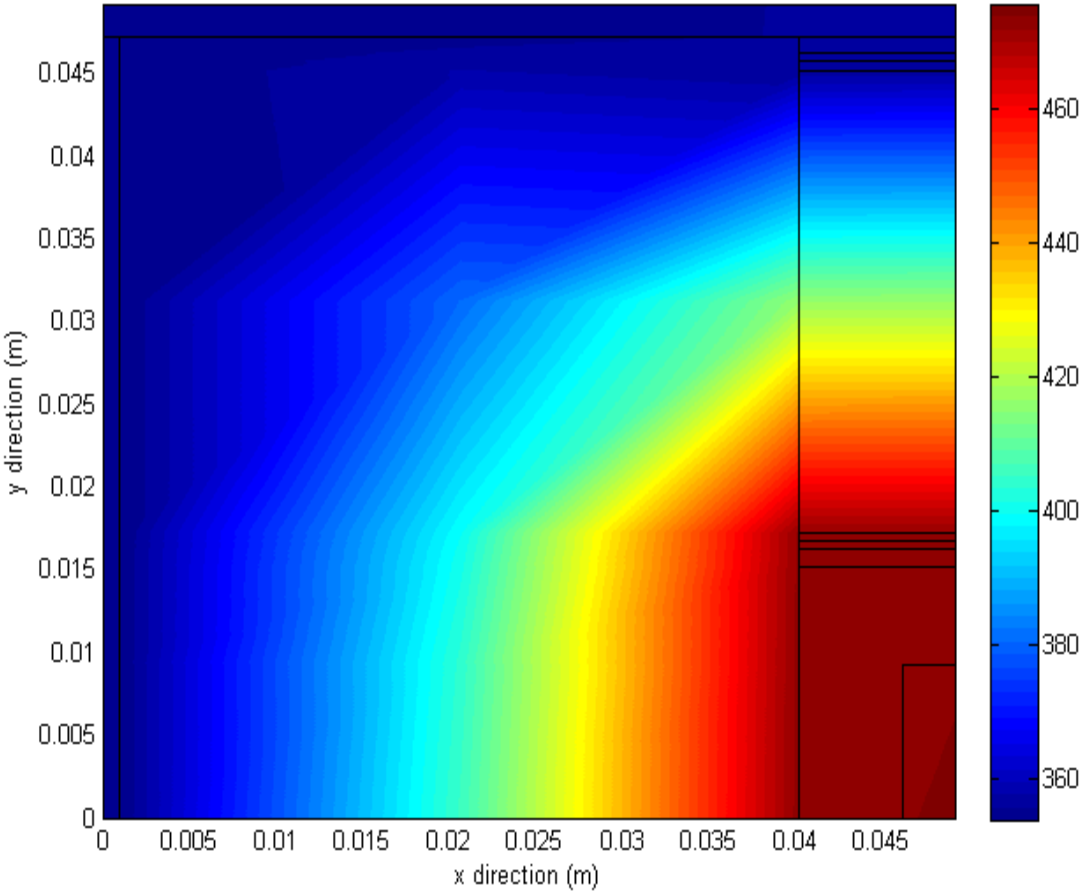
3. Design

- Fuel: SrO has high sp. power, high melting pt, soluble in water
- Pellet shield: Tungsten
- Casing: Stainless steel
- Legs: Bi_2Te_3 suitable for temp range
- Heat sink: Al plate with white paint


Aluminium with MgO paint
Stainless steel
Min-K insulation
Min-K insulation
Tungsten
Strontium Oxide
Thermo-electric module

Steady State Temperature distribution (in K) for final design.

T < 363K at y face



Performance

$(T_{hot} - T_{cold})_{legs}$	$R_{in_{generat}}$	$I_{sc_{generat}}$	$V_{oc_{generato}}$	Max Temp @centre	Matched load power output	Eff.
°K	Ω	A	V	°K	W	%
116.04	363.56	0.0170	12.34	475.8	**0.0523**	6.95

assumes Bi_2Te_3 legs and face temp limit of 90°C

Mass budget

Parameter	Mass (g)
Fuel pellet mass	1.9
Shield mass	158.8
Insulation mass	58.4
Casing mass	142
Ceramic mass	4.4
Conductor	5.1
Legs	119
Radiator	26.1
Silicon layer	1.3
Total mass	**517**

4. Future work

- Safety (launch, impact, re-entry) calculations
- Commercial availability of Strontium-90
- Costing
- Build it! First with a heat source analogue.