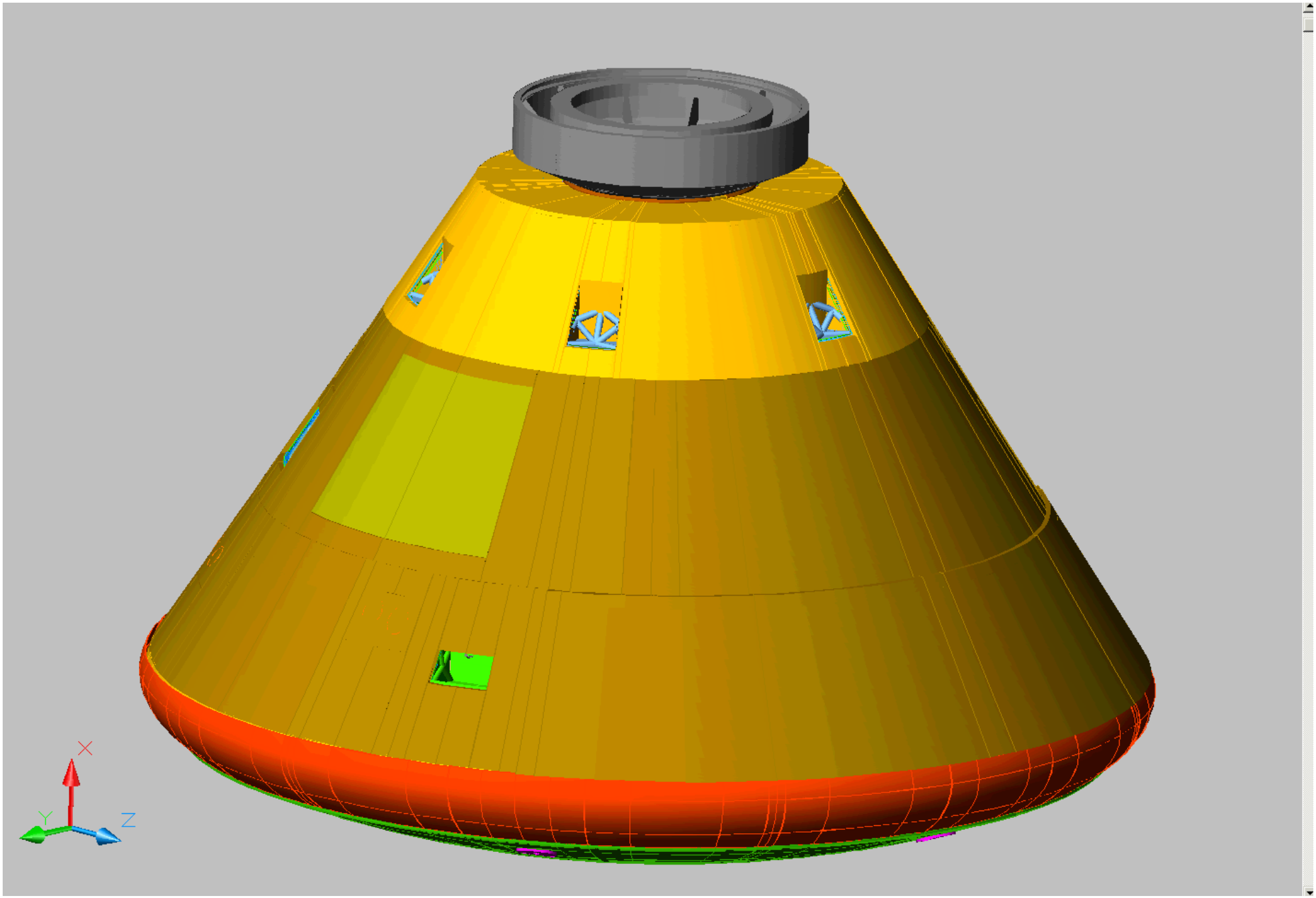
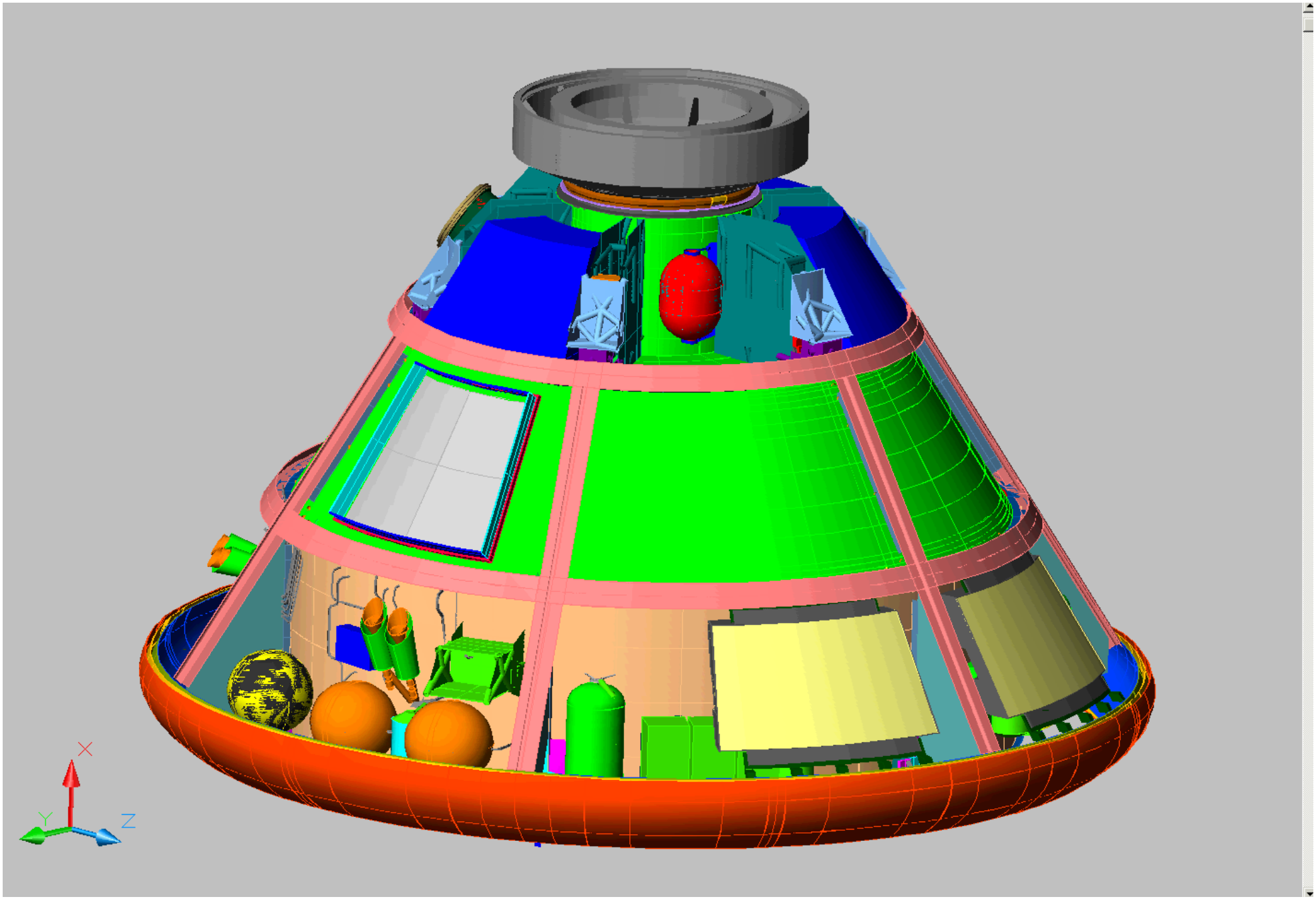
GUNNS

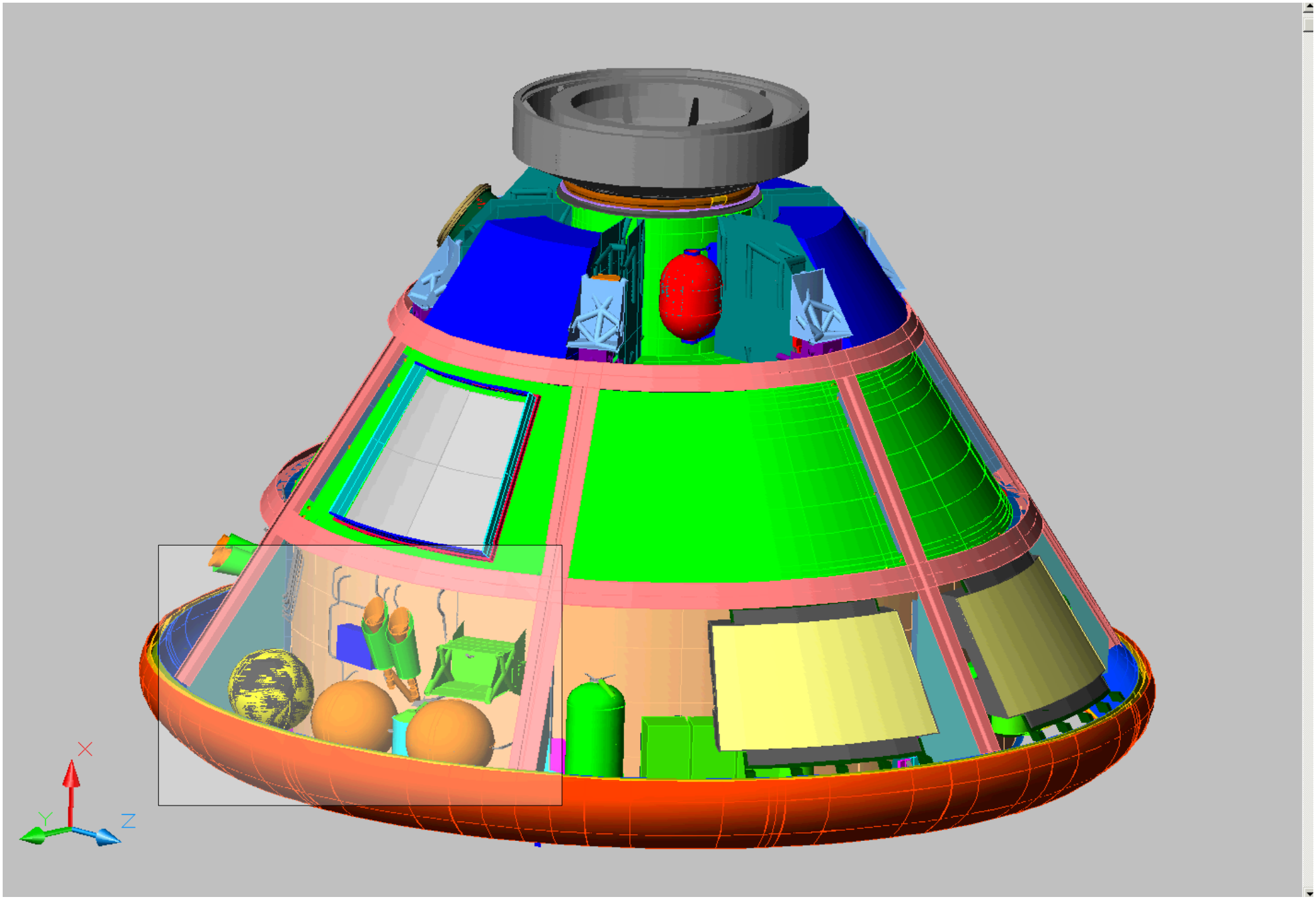
	Fluid	Electrical	Thermal
potential:	ΔP	ΔV	ΔT
flow:	$\dot{m}$	I	$\dot{Q}$

GUNNS

thermal network?


X
Y
Z

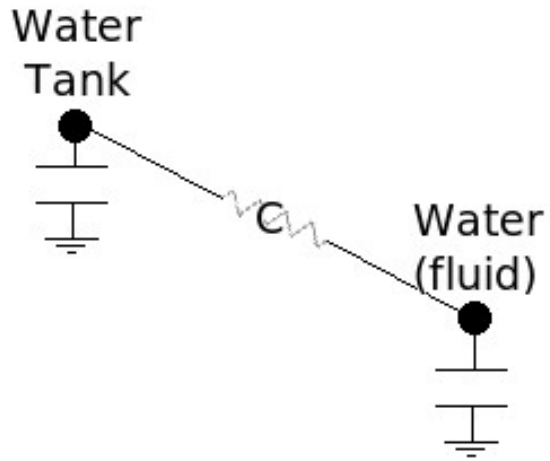

X
Y
Z


X
Y
Z

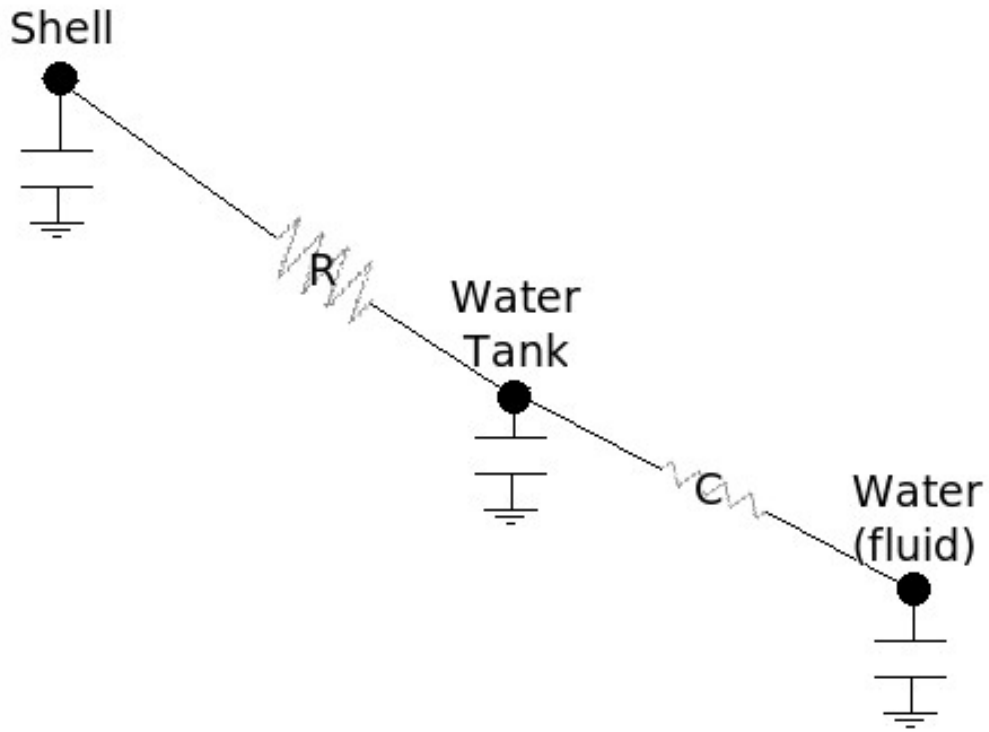
- Construct thermal network in GUNNS

- Construct thermal network in GUNNS

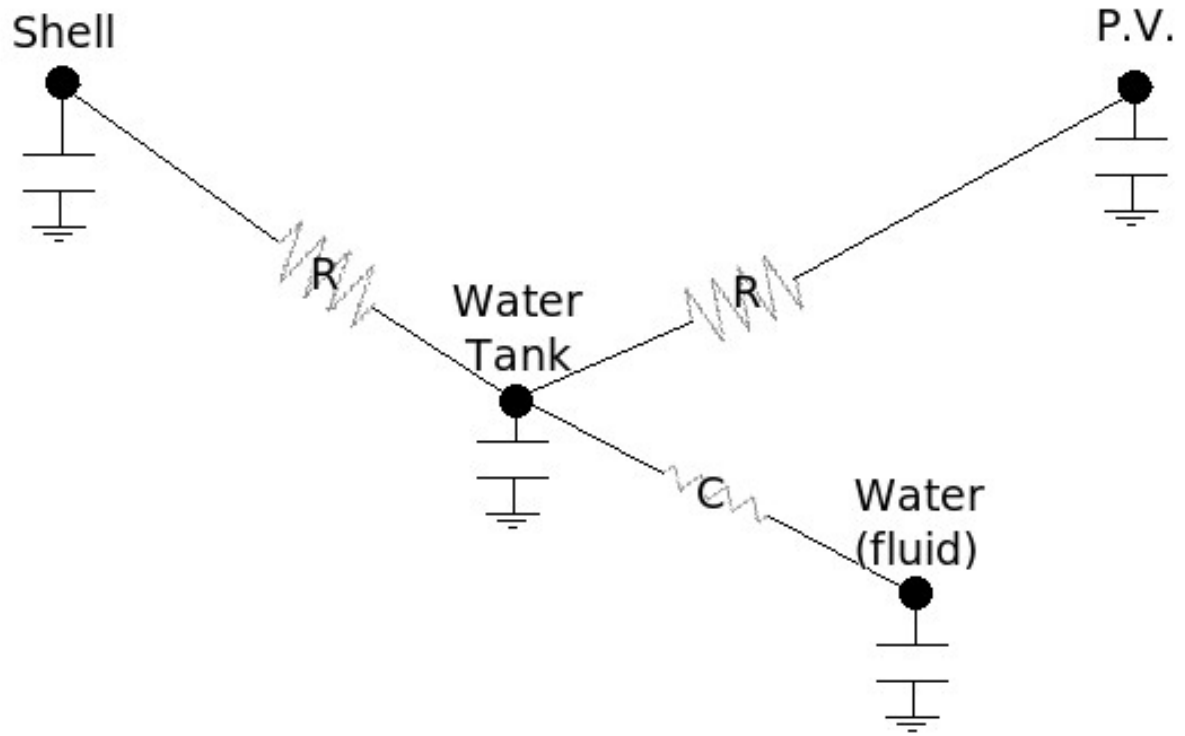
- Construct thermal network in GUNNS



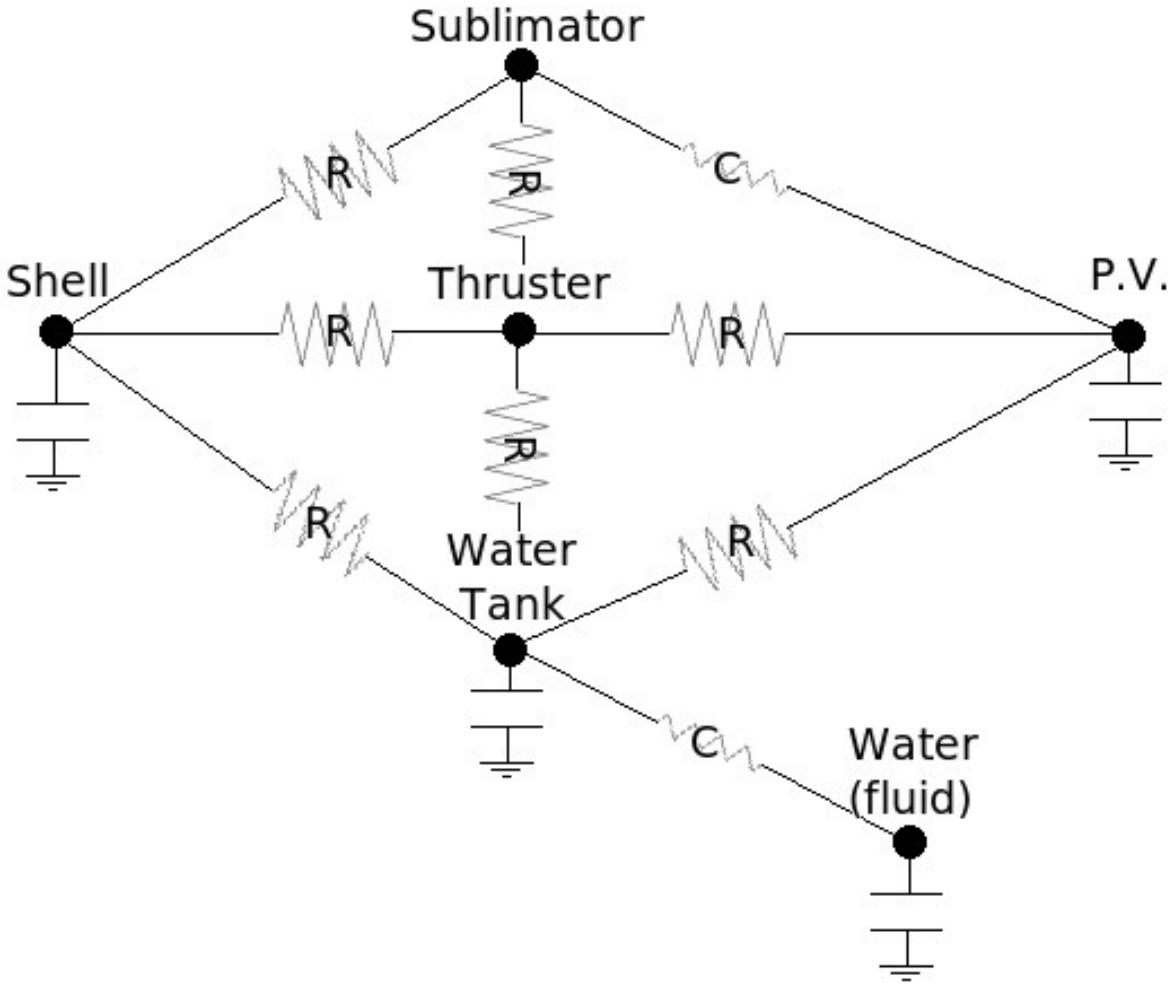
- Construct thermal network in GUNNS

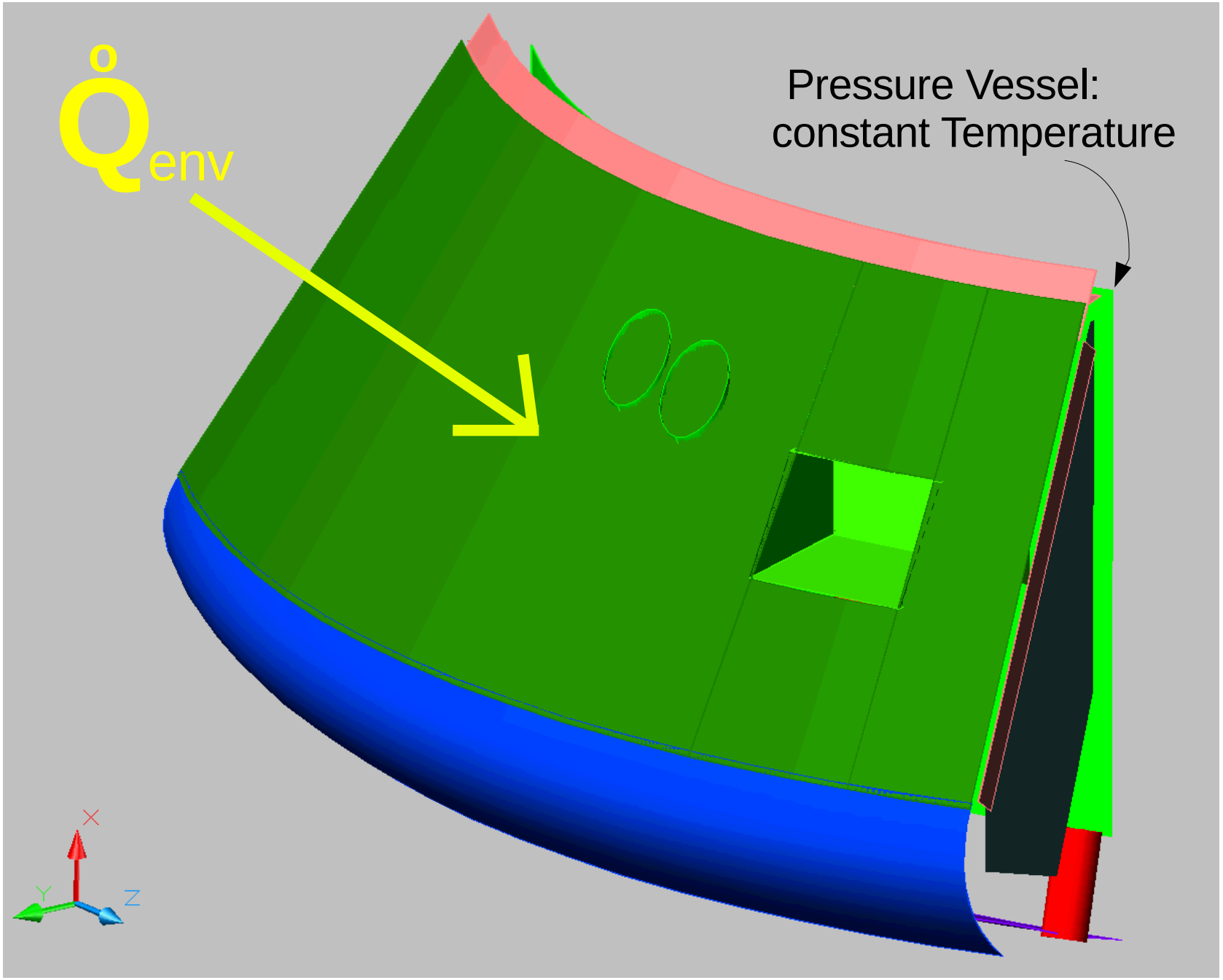


- Construct thermal network in GUNNS

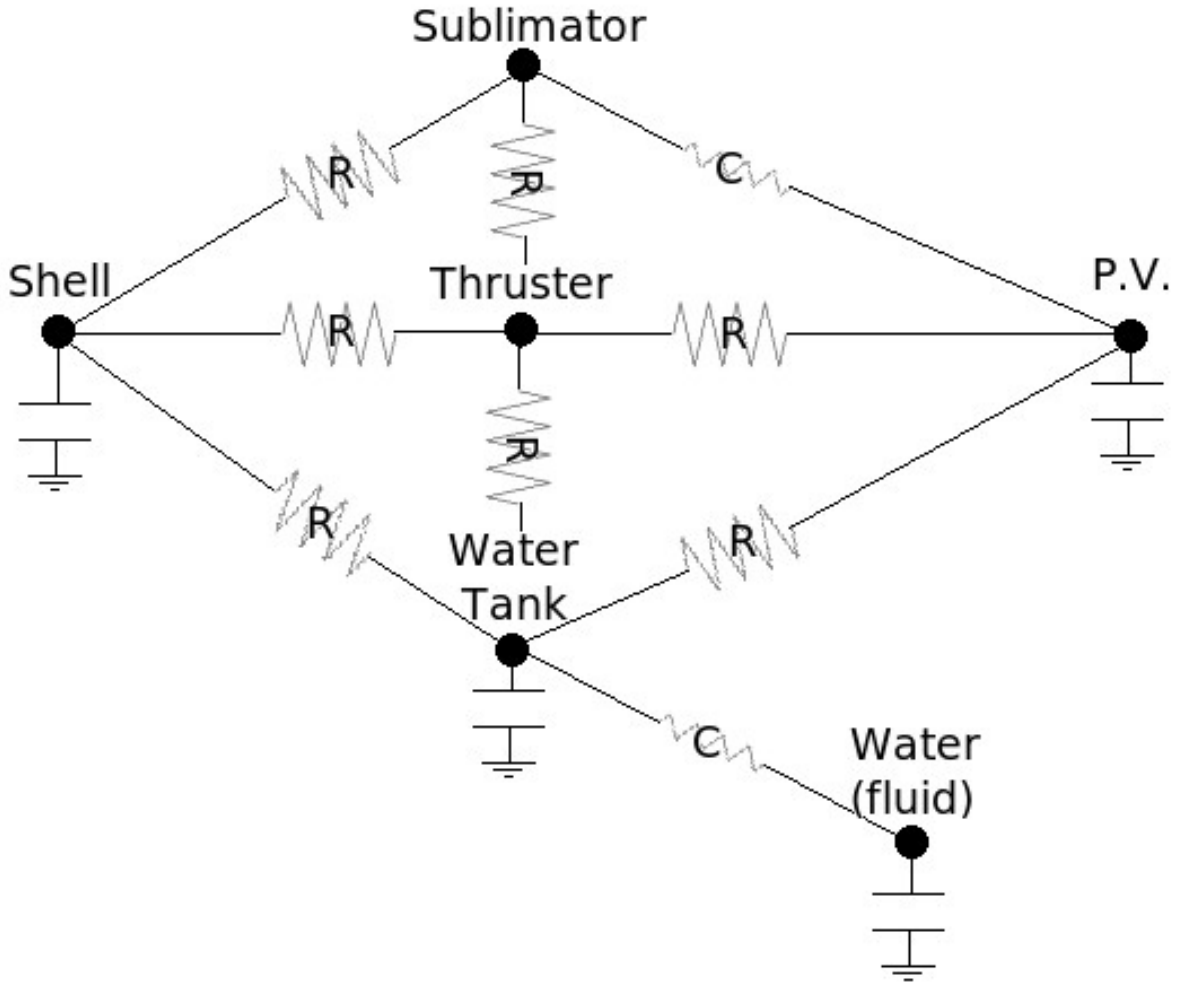


- Construct thermal network in GUNNS

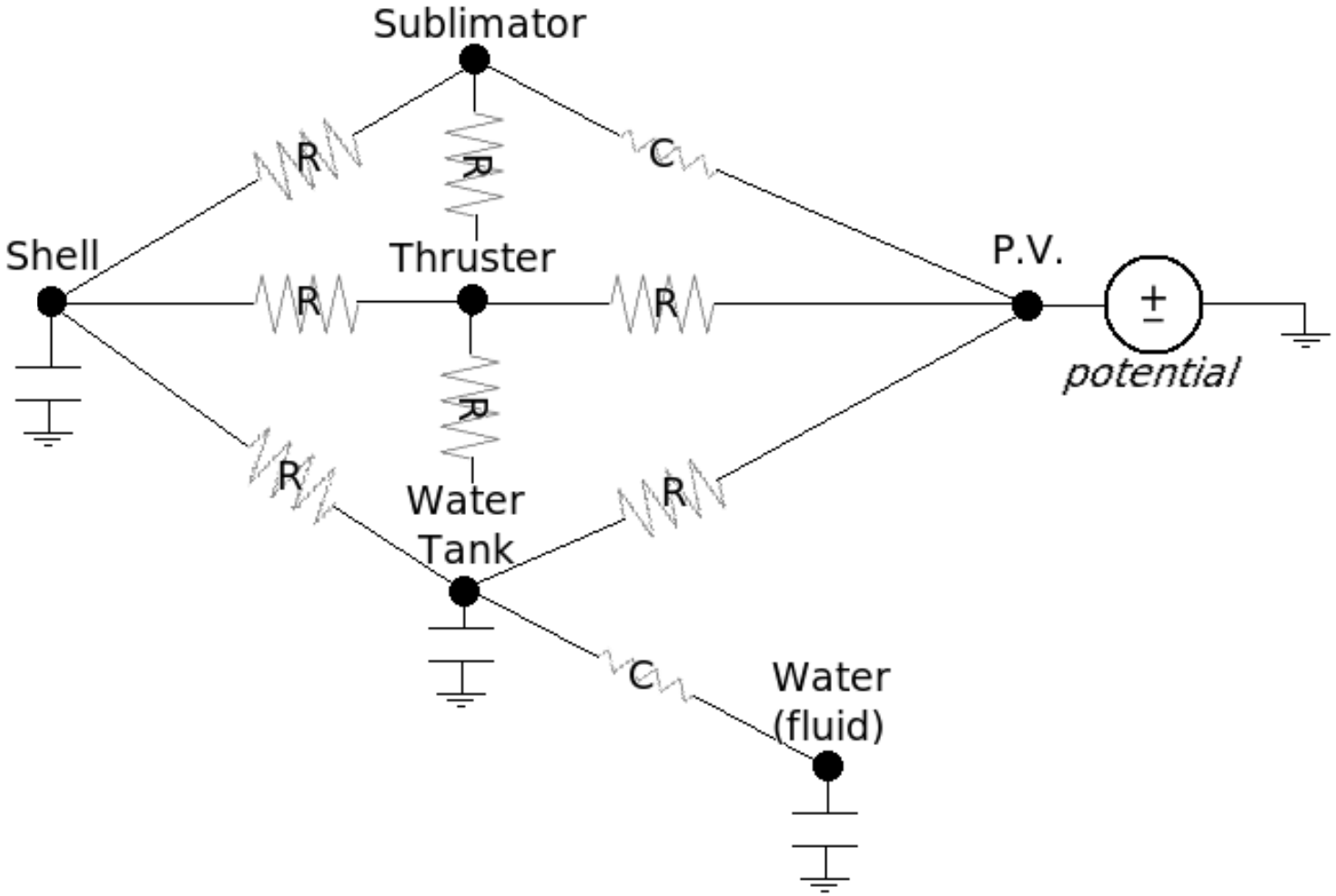



$\dot{Q}_{env}$
Pressure Vessel:
constant Temperature
X
Y
Z

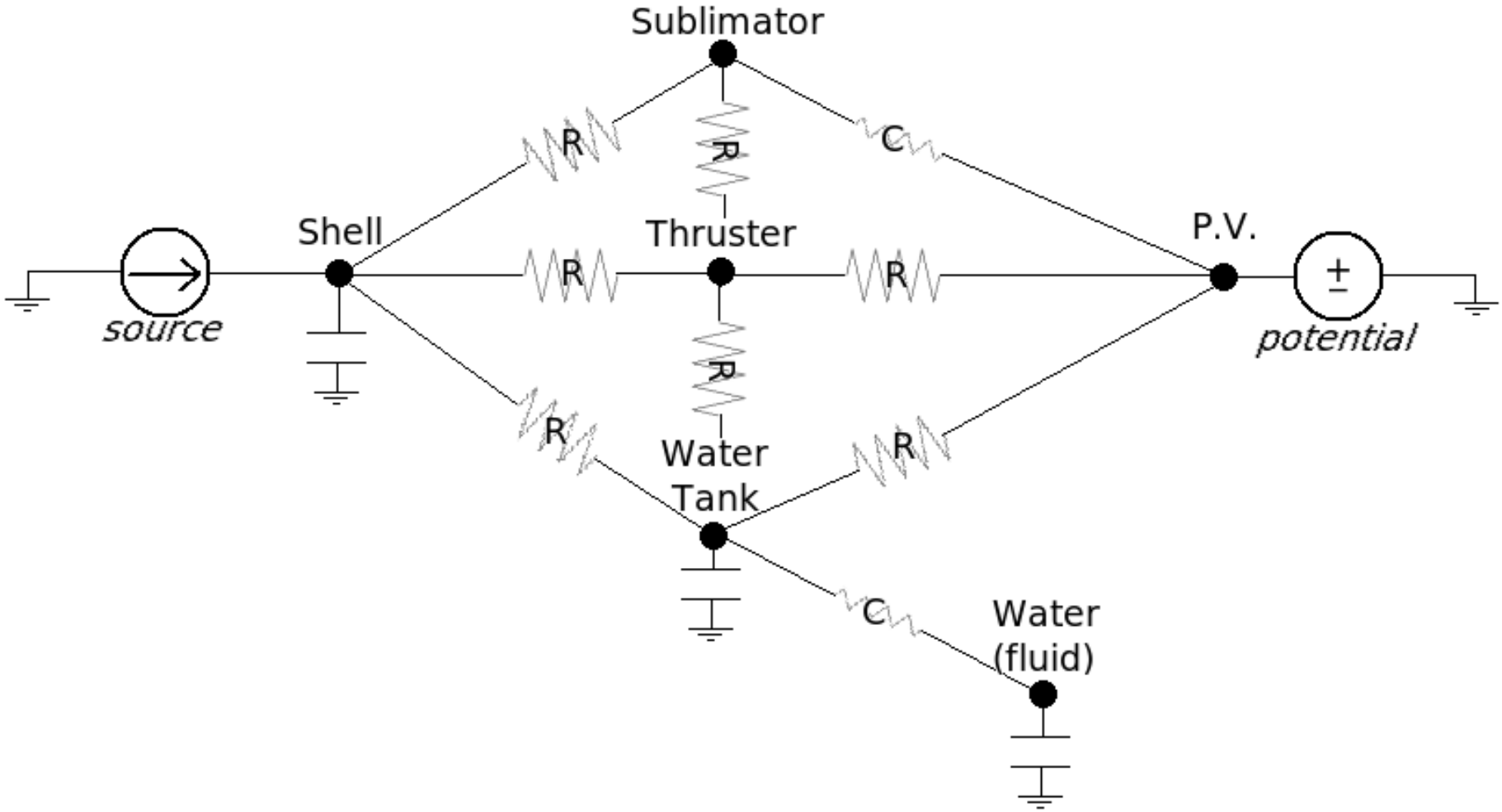
- Construct thermal network in GUNNS

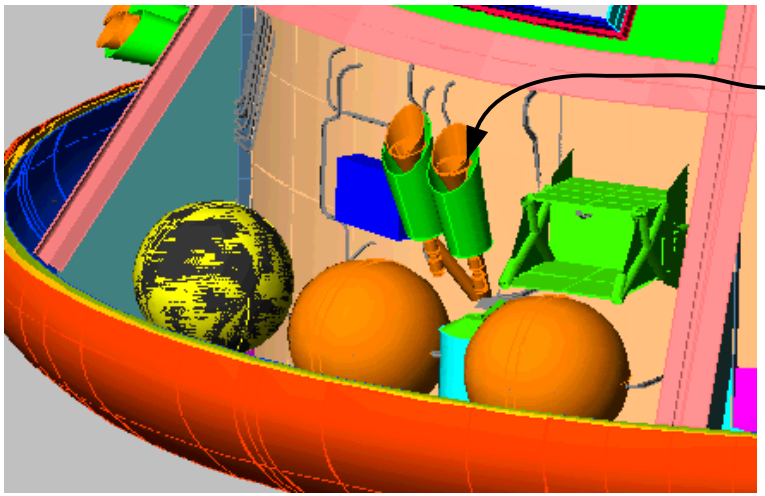


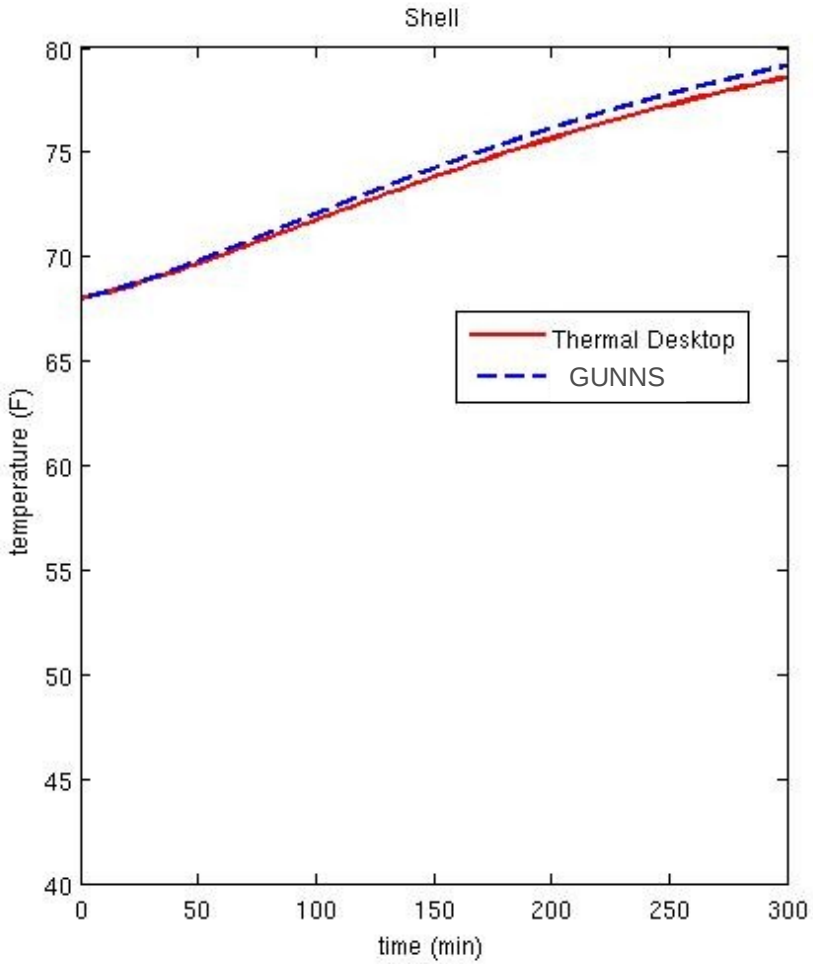
- Construct thermal network in GUNNS

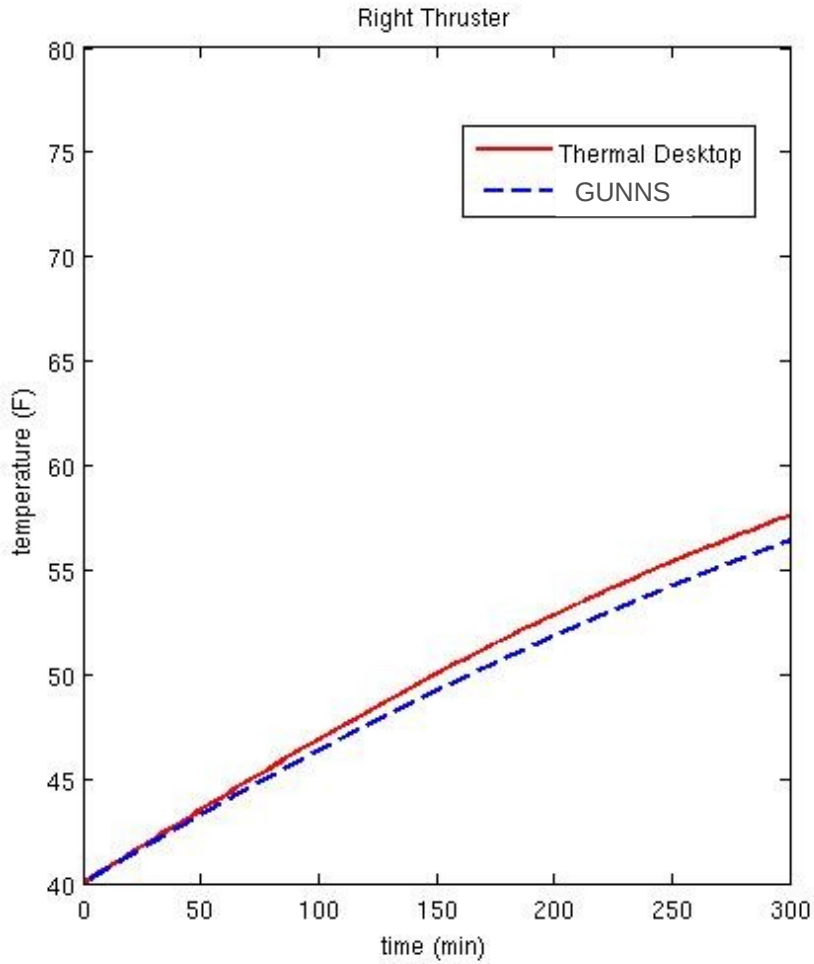


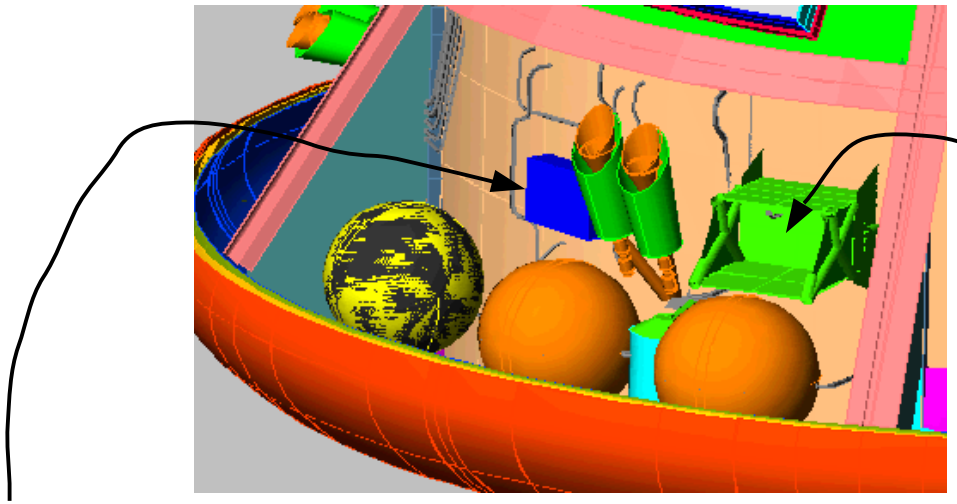
- Construct thermal network in GUNNS

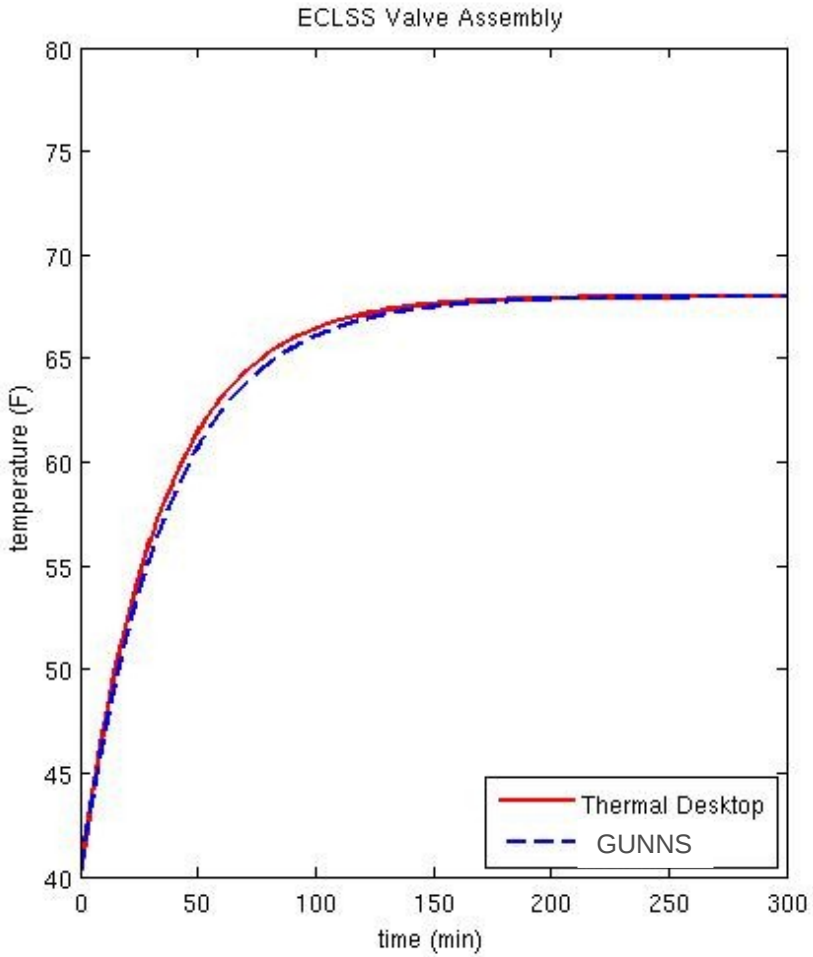


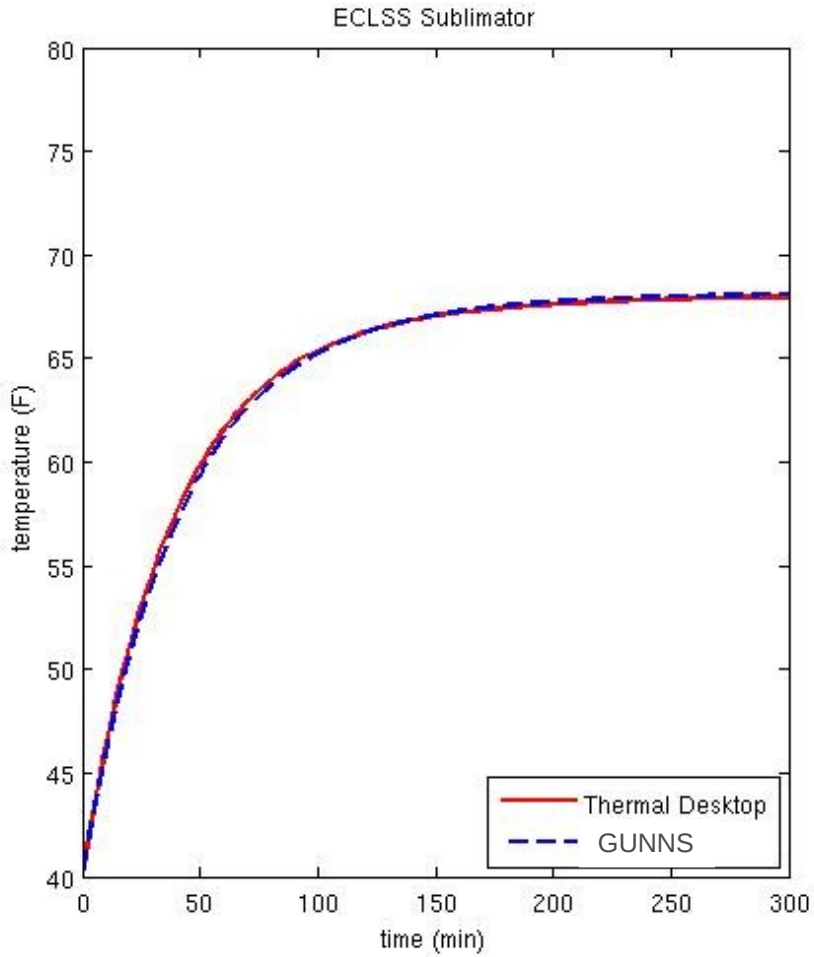


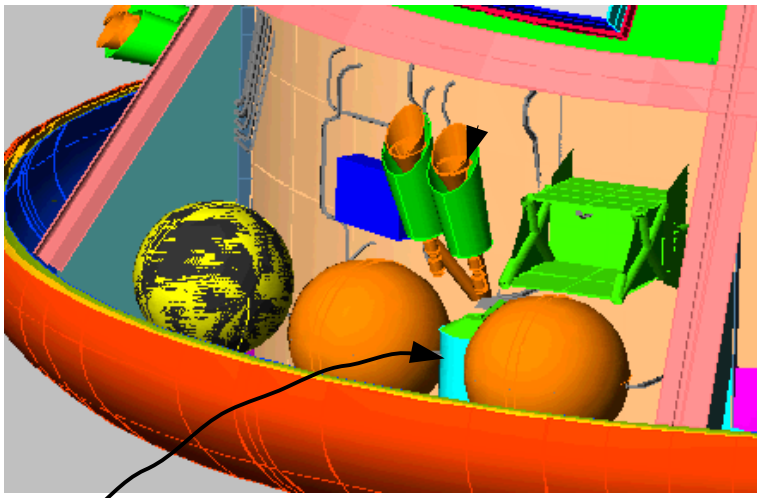

Shell
temperature (F)
time (min)
Thermal Desktop
GUNNS
80
75
70
65
60
55
50
45
40
0
50
100
150
200
250
300

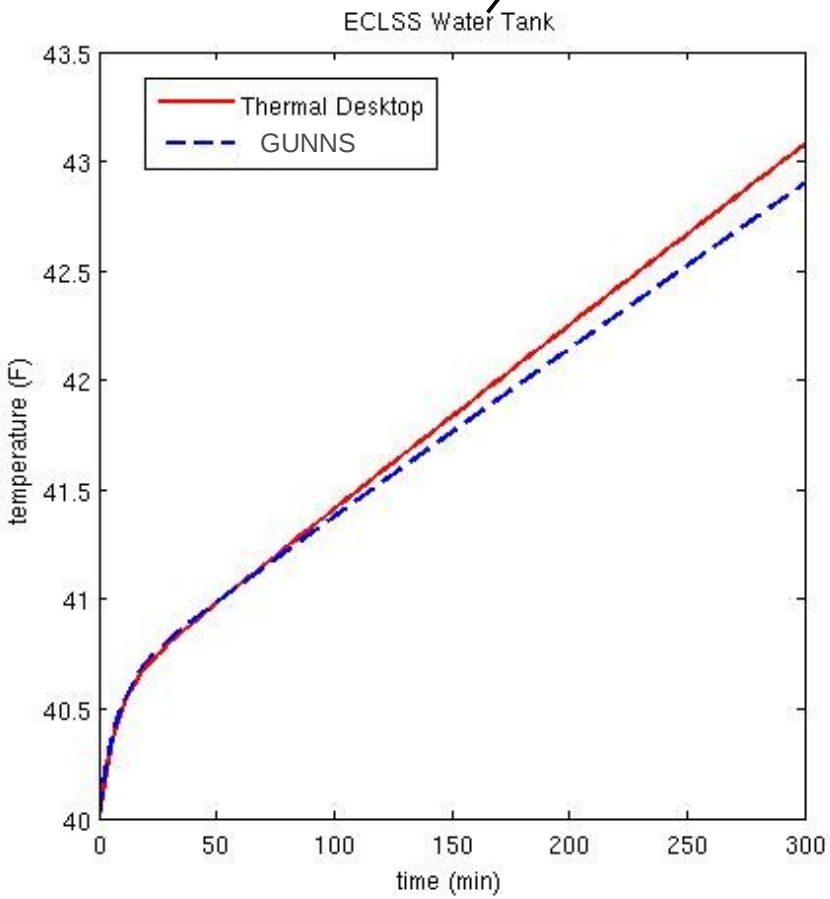

Right Thruster
temperature (F)
time (min)
Thermal Desktop
GUNNS
80
75
70
65
60
55
50
45
40
0
50
100
150
200
250
300

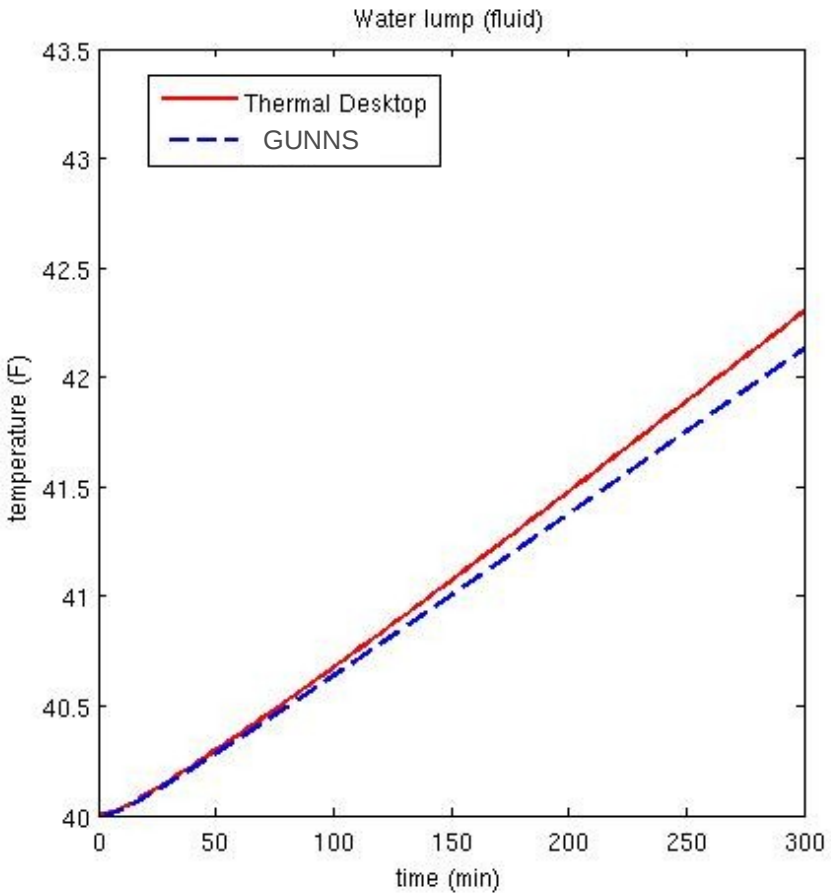



ECLSS Valve Assembly
temperature (F)
time (min)
Thermal Desktop
GUNNS
80
75
70
65
60
55
50
45
40
0
50
100
150
200
250
300


ECLSS Sublimator
temperature (F)
time (min)
Thermal Desktop
GUNNS
80
75
70
65
60
55
50
45
40
0
50
100
150
200
250
300




ECLSS Water Tank
Thermal Desktop
GUNNS
temperature (F)
time (min)
43.5
43
42.5
42
41.5
41
40.5
40
0
50
100
150
200
250
300


Water lump (fluid)
Thermal Desktop
GUNNS
temperature (F)
time (min)
43.5
43
42.5
42
41.5
41
40.5
40
0
50
100
150
200
250
300

Transport Equations

$$\underbrace{\frac{\partial \rho\phi}{\partial t}}_{\text{Accumulation}} + \underbrace{\nabla\cdot(\rho\mathbf{u}\phi)}_{\text{Convection}} = \underbrace{\nabla\cdot(\Gamma\nabla\phi)}_{\text{Diffusion}} + \underbrace{S_\phi}_{\text{Source}}$$

mass:

$$\frac{\partial \rho}{\partial t} + \nabla\cdot(\rho\mathbf{u}) = 0$$

momentum:

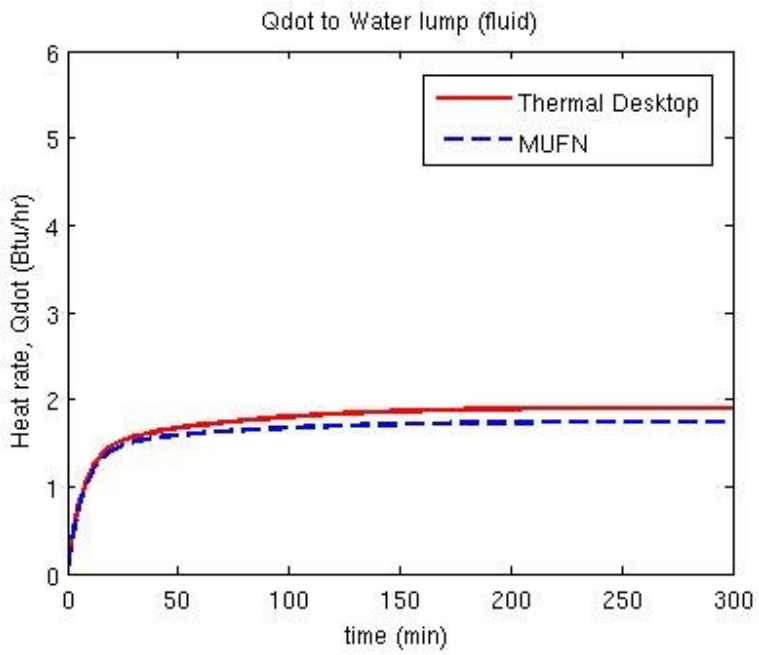
$$\frac{\partial \rho u}{\partial t} + \nabla\cdot(\rho\mathbf{u}u) = \nabla\cdot(\mu\nabla u) - \frac{\partial p}{\partial x} + \rho g_x$$

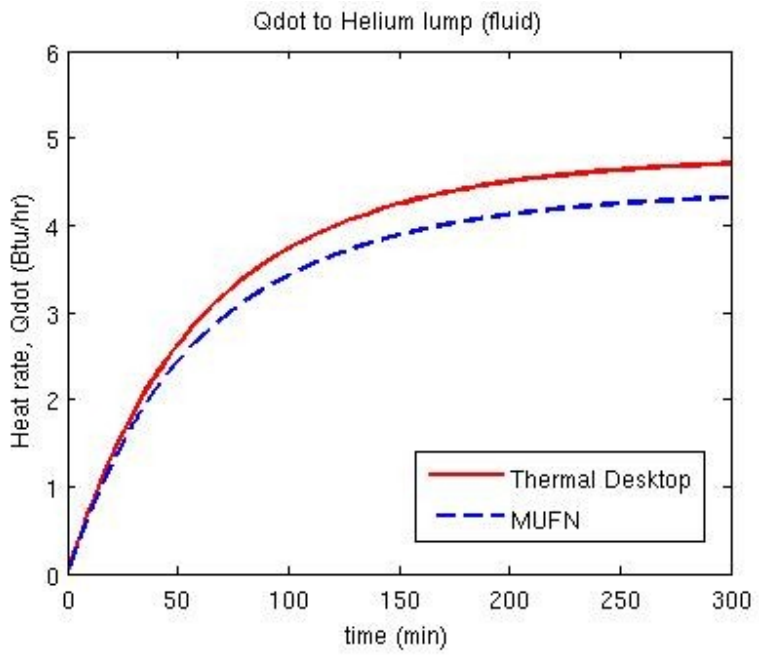
energy:

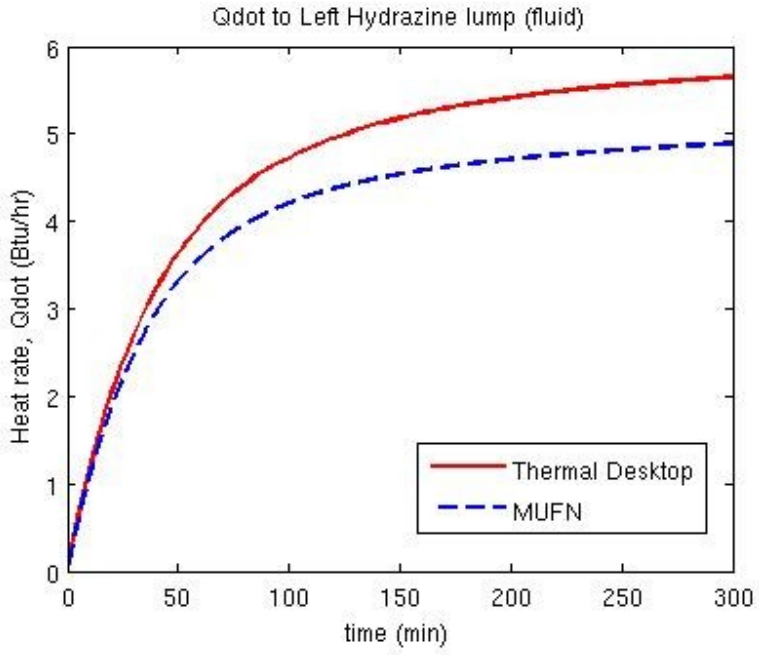
$$\frac{\partial \rho T}{\partial t} + \nabla\cdot(\rho\mathbf{u}T) = \nabla\cdot\left(\frac{k}{c_p}\nabla T\right)$$

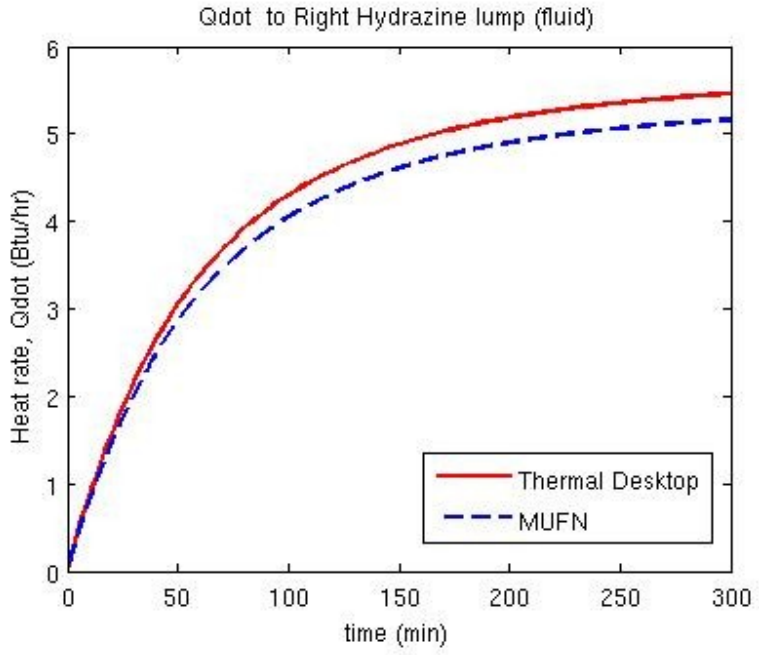
conduction: $\dot{Q} = \frac{k A}{\Delta x} \Delta T$

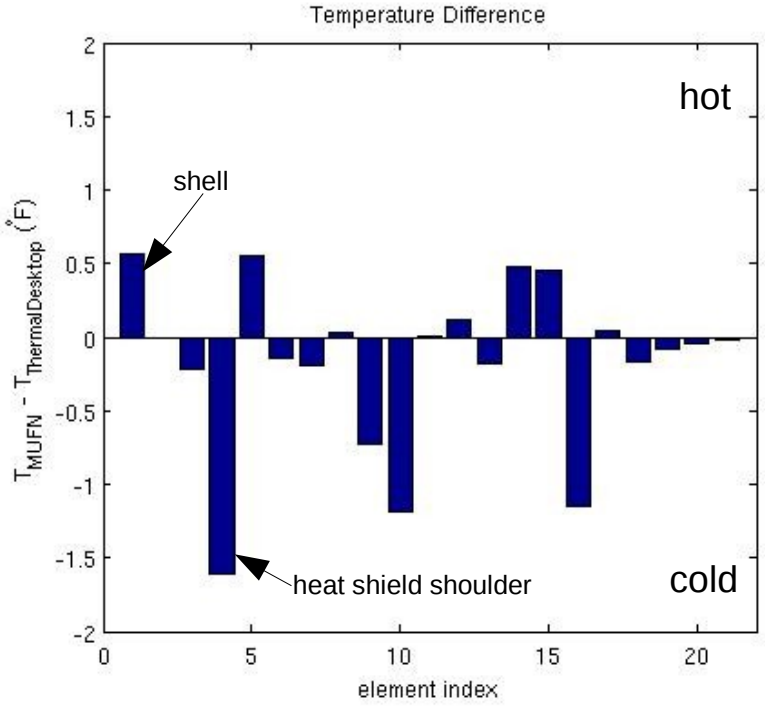
radiation: $\dot{Q} = \sigma \epsilon A F (T_o^4 - T^4)$

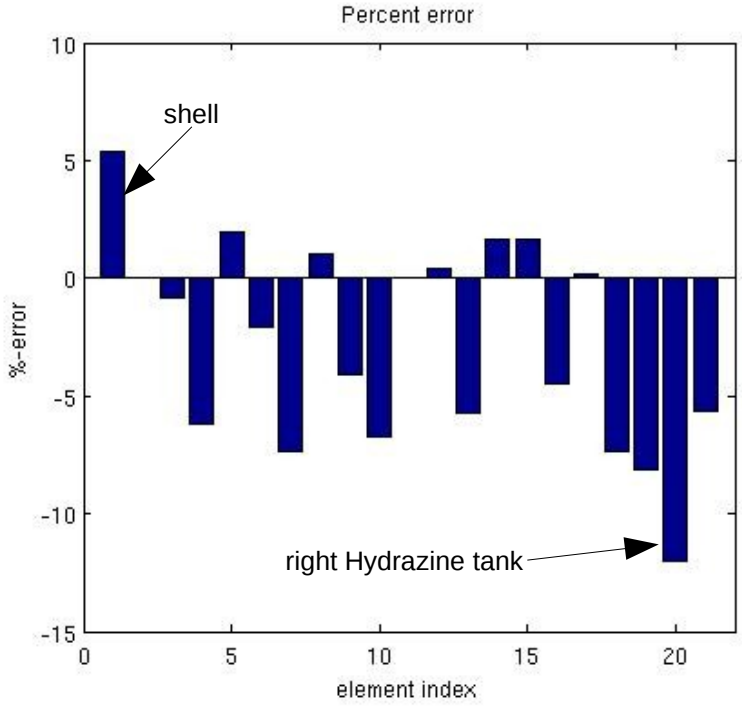

Qdot to Water lump (fluid)
Thermal Desktop
MUFN
Heat rate, Qdot (Btu/hr)
time (min)
0
1
2
3
4
5
6
0
50
100
150
200
250
300


Qdot to Helium lump (fluid)
Thermal Desktop
MUFN
Heat rate, Qdot (Btu/hr)
time (min)
0
1
2
3
4
5
6
0
50
100
150
200
250
300


Qdot to Left Hydrazine lump (fluid)
Thermal Desktop
MUFN
Heat rate, Qdot (Btu/hr)
time (min)
0
1
2
3
4
5
6
0
50
100
150
200
250
300


Qdot to Right Hydrazine lump (fluid)
Thermal Desktop
MUFN
Heat rate, Qdot (Btu/hr)
time (min)
0
1
2
3
4
5
6
0
50
100
150
200
250
300

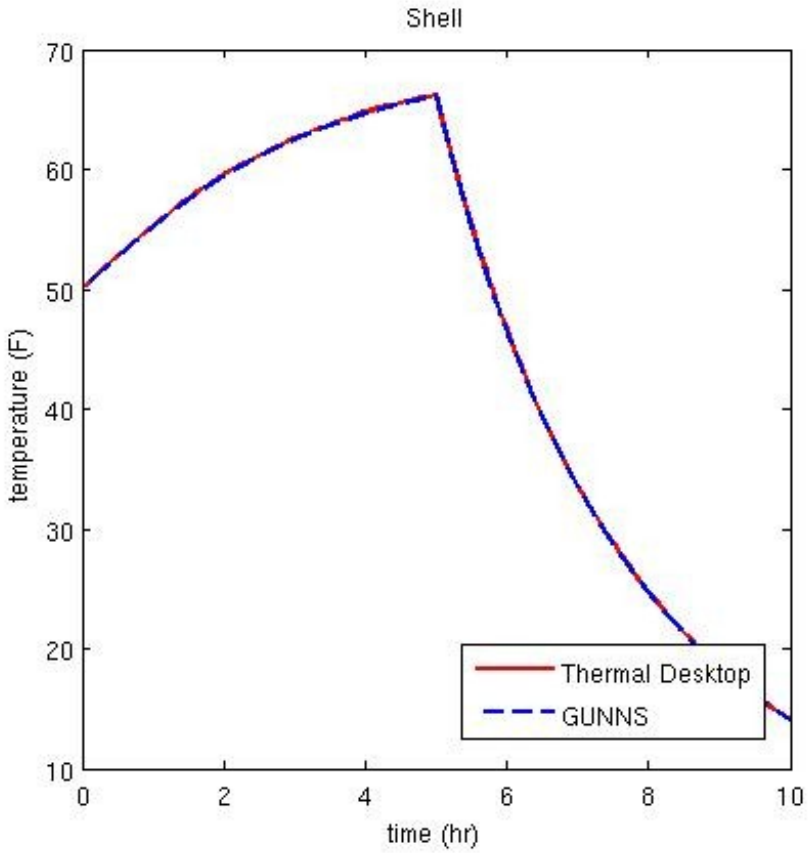


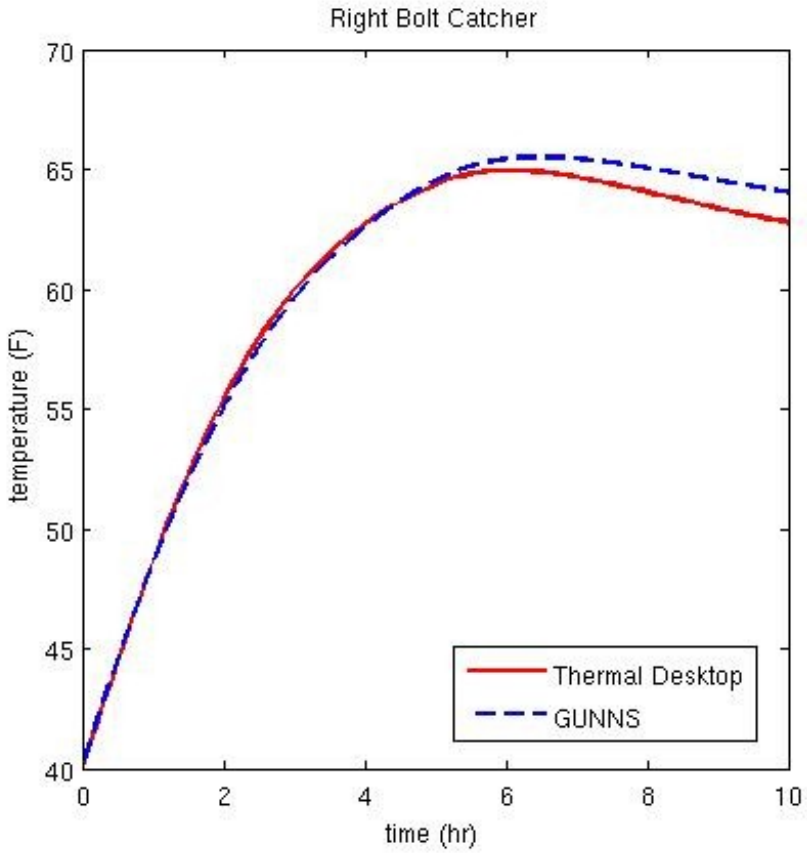


$$\% \text{ error} = \frac{\Delta T_{MUFN} - \Delta T_{thermal\ desktop}}{\Delta T_{thermal\ desktop}} \times 100$$

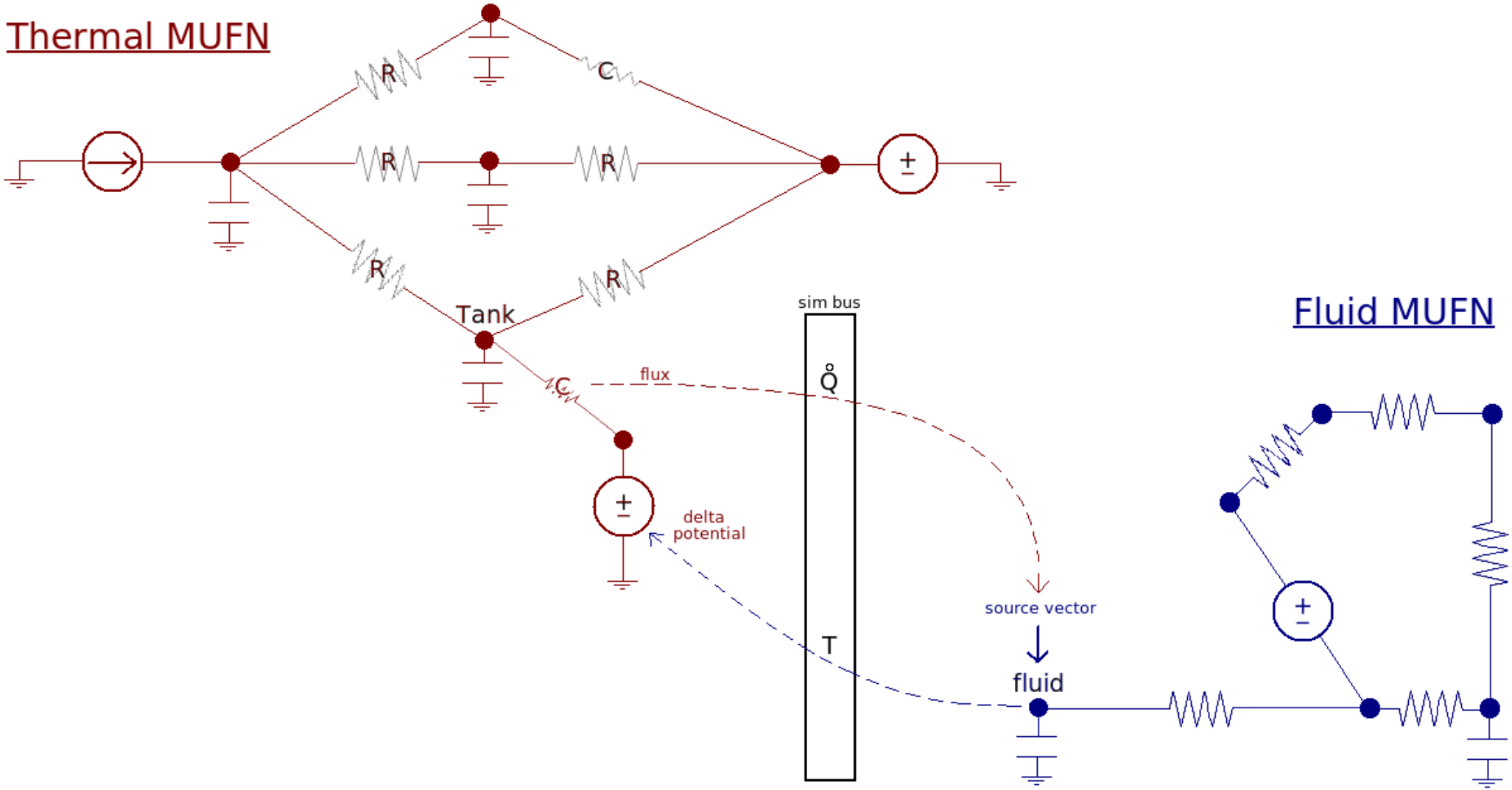
where, $\Delta T = T_{@\ 5\ hr} - T_{@\ 0\ hr}$

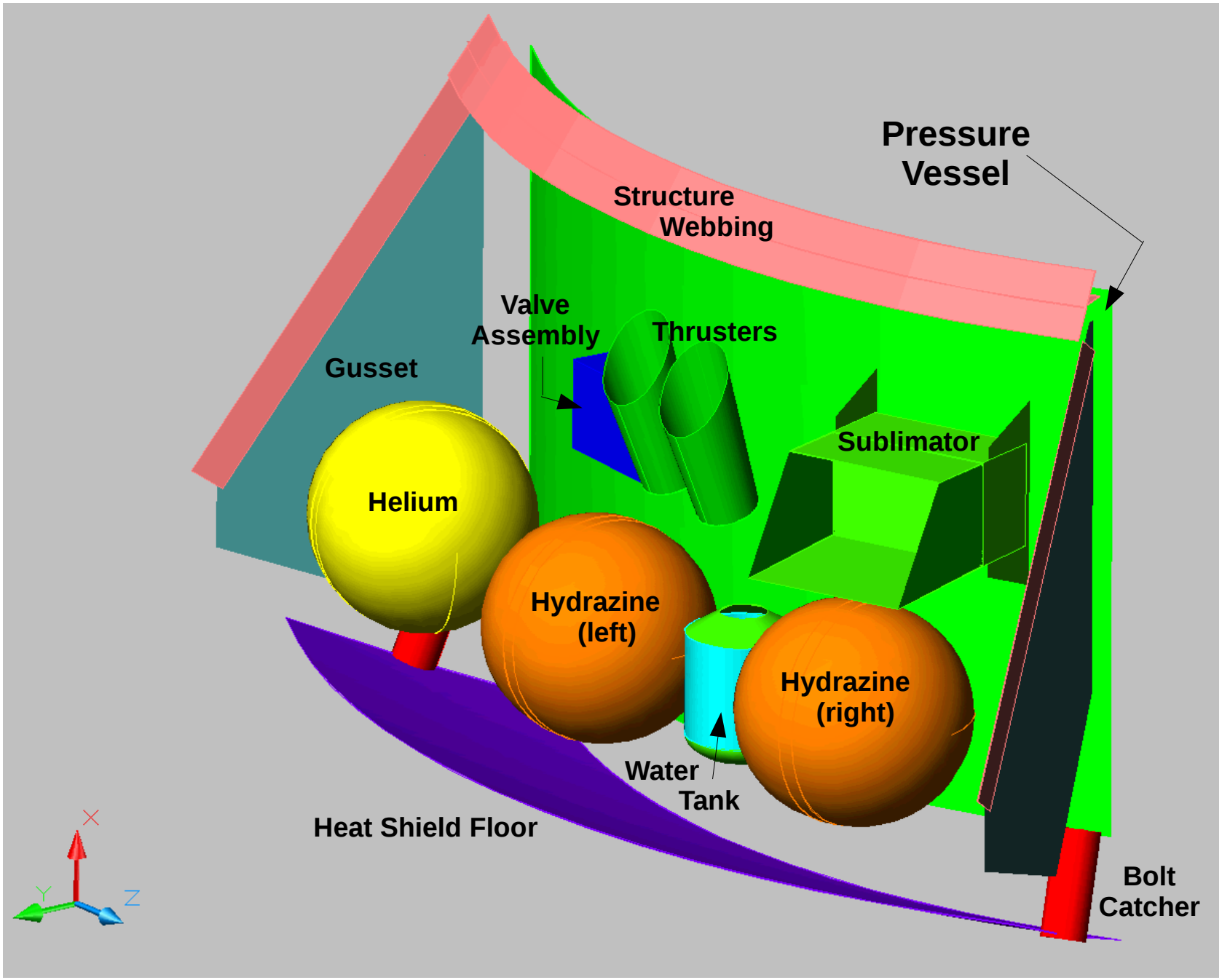
Eclipse @ 5 hr

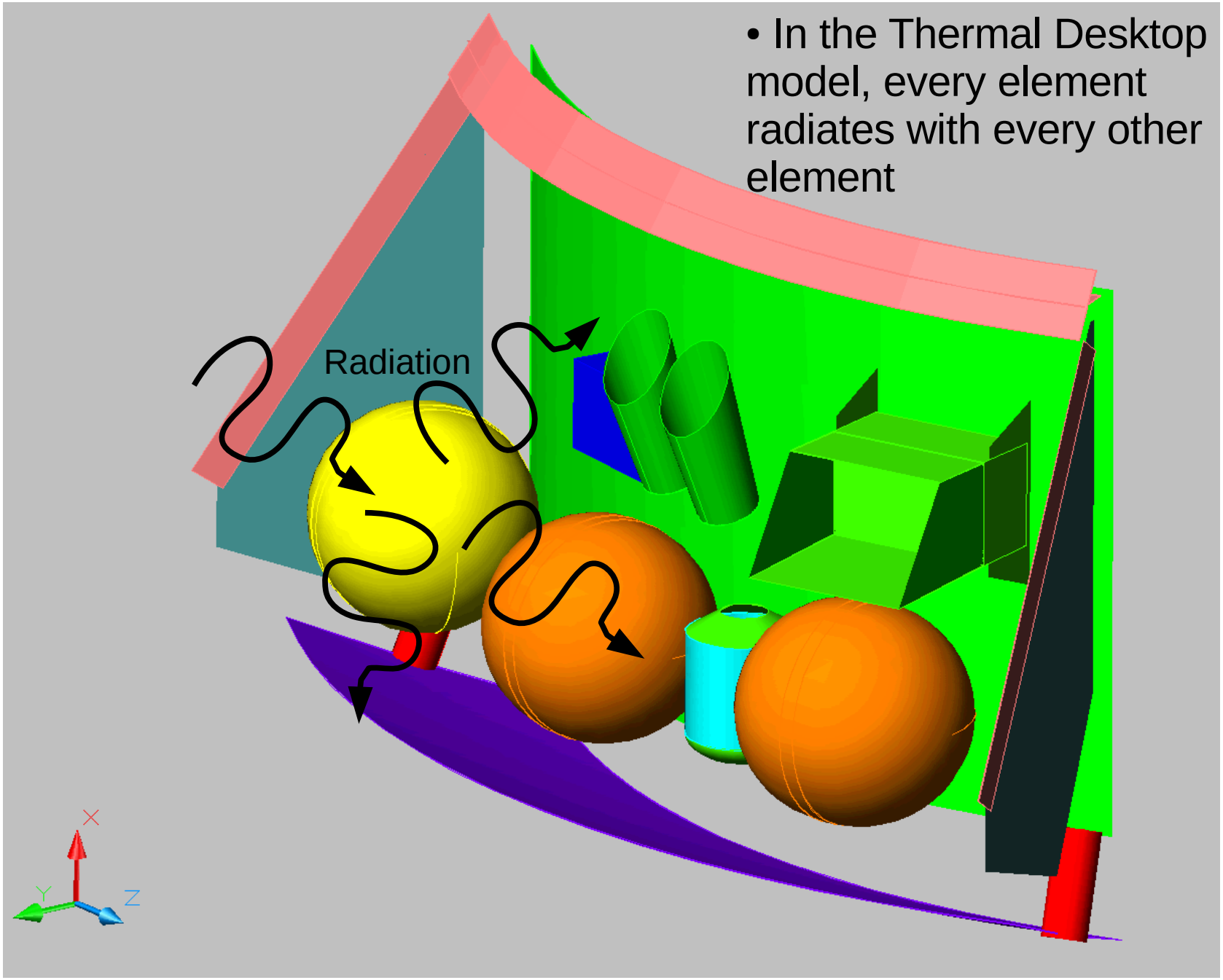

Shell
temperature (F)
time (hr)
Thermal Desktop
GUNNS

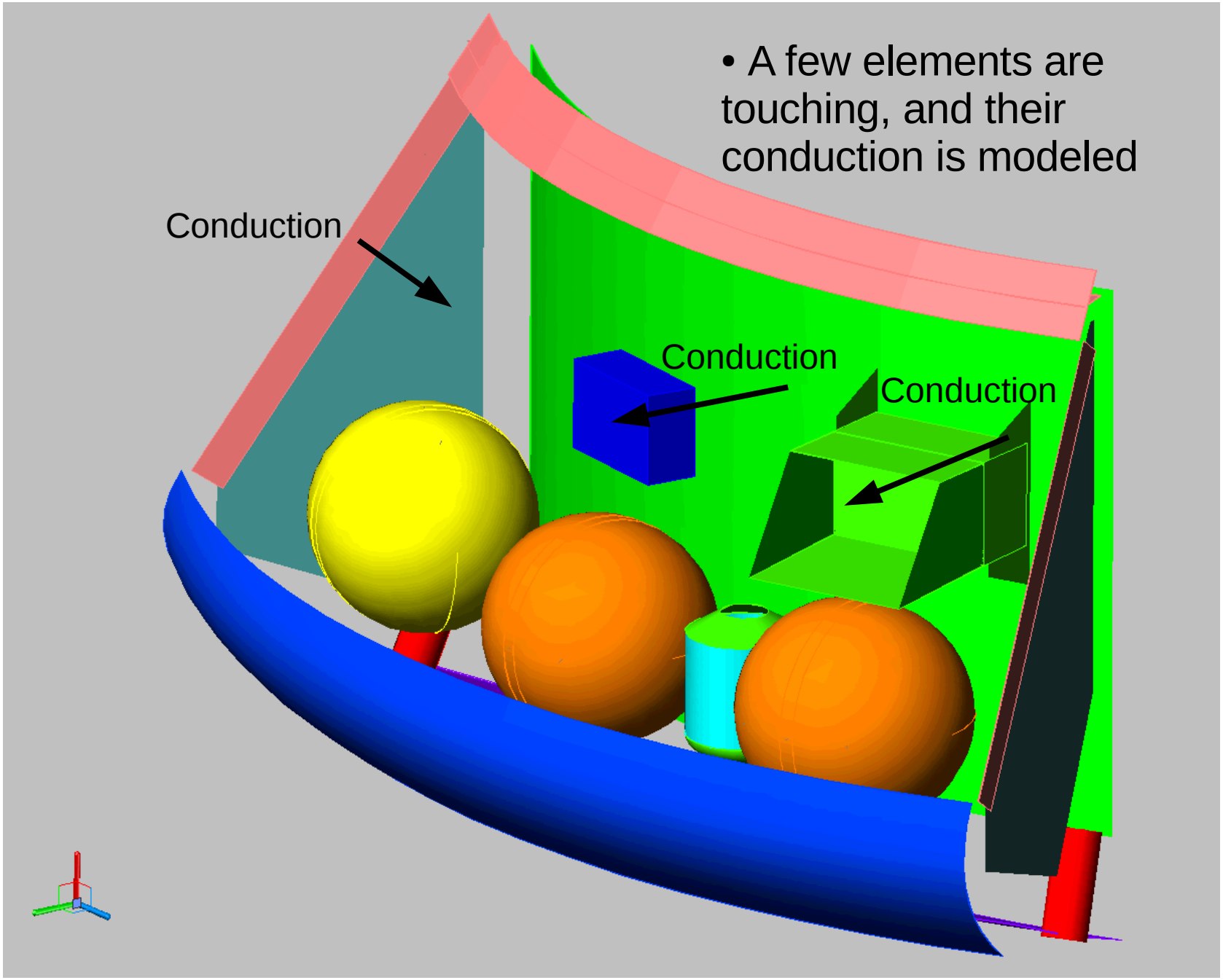

Right Bolt Catcher
temperature (F)
time (hr)
Thermal Desktop
GUNNS

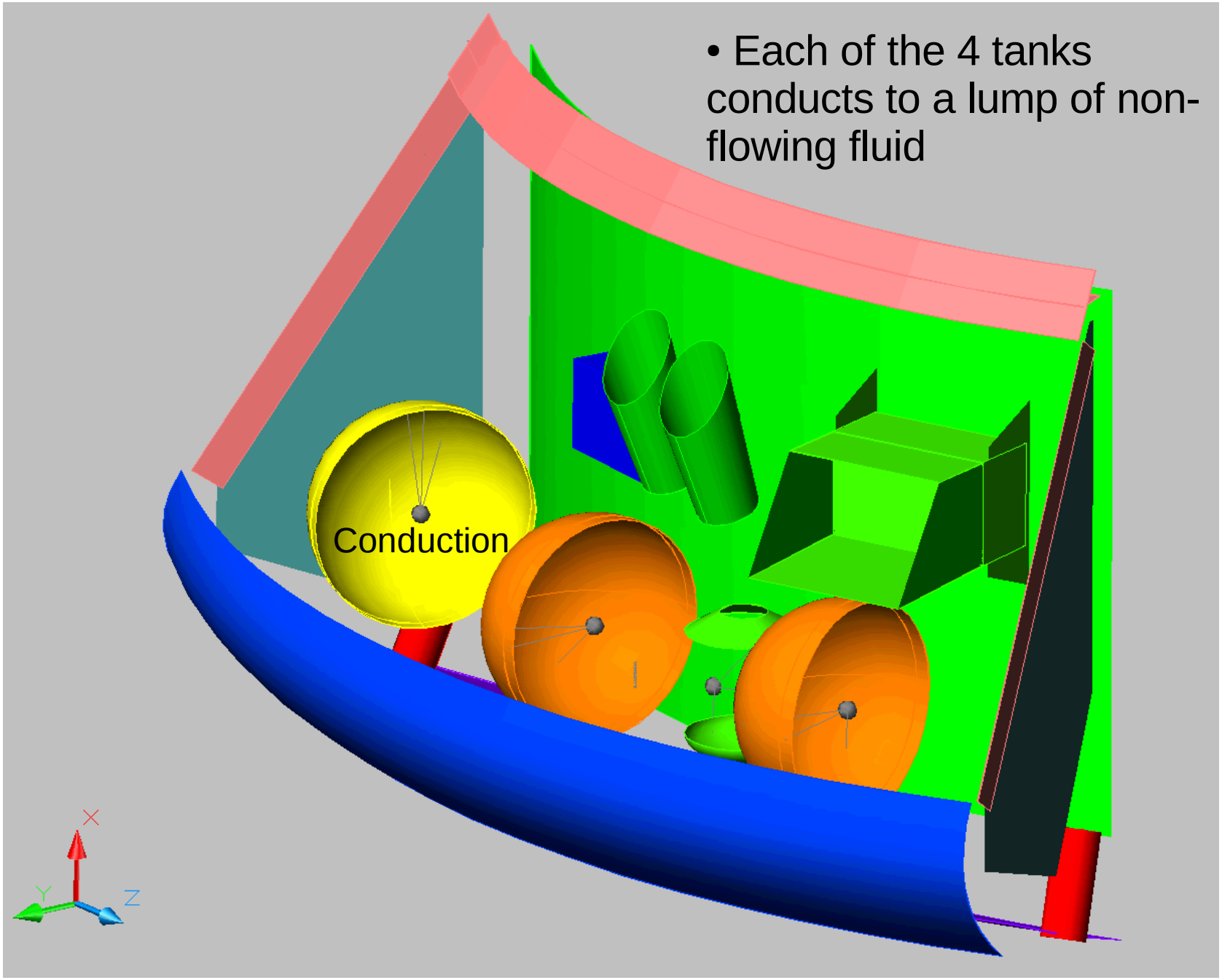
Exchanging Temperatures -- **Tank**

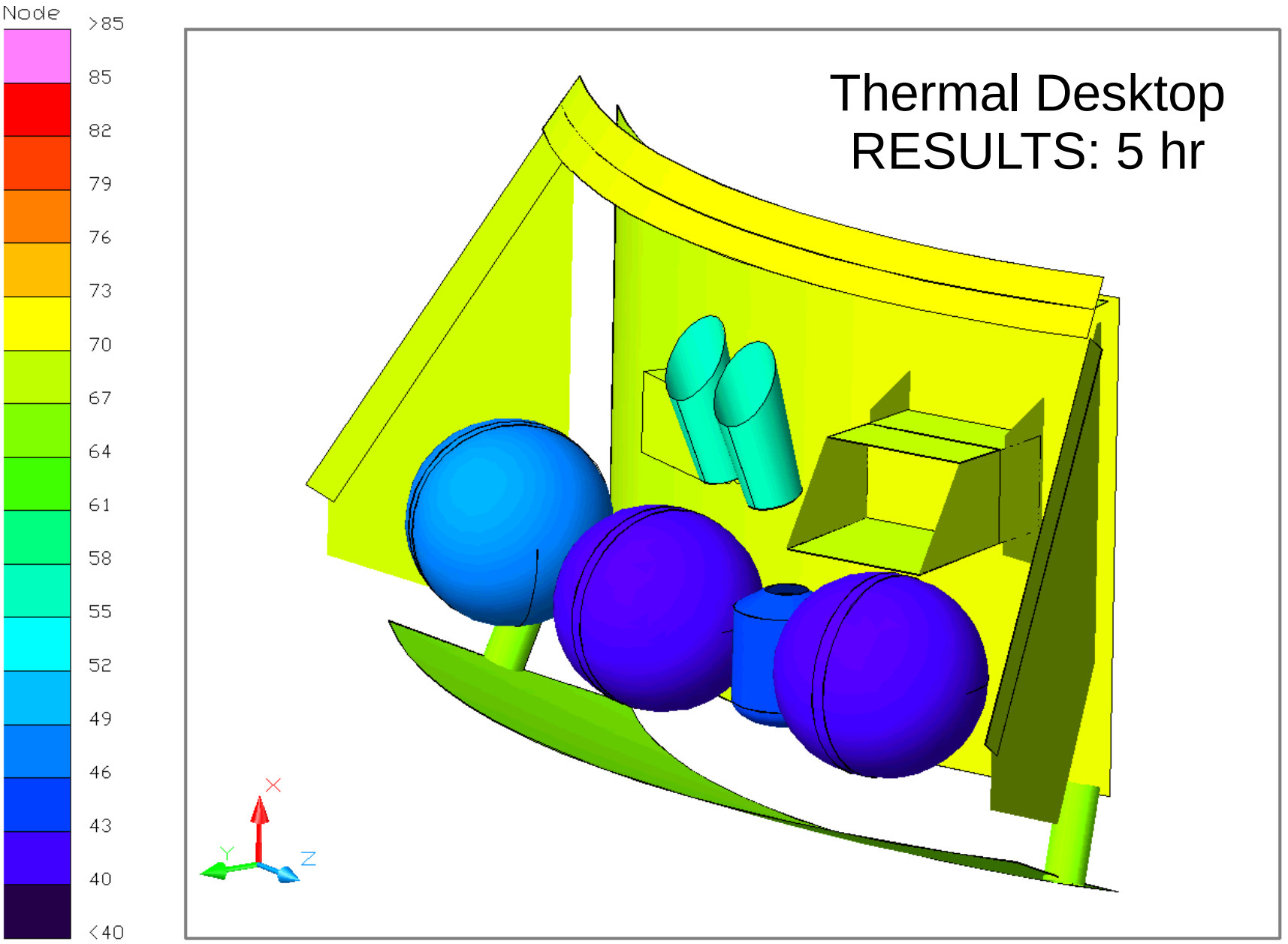



Pressure
Vessel
Structure
Webbing
Valve
Assembly
Thrusters
Gusset
Sublimator
Helium
Hydrazine
(left)
Hydrazine
(right)
Water
Tank
Heat Shield Floor
Bolt
Catcher
X
Y
Z


• In the Thermal Desktop model, every element radiates with every other element
Radiation
X
Y
Z


• A few elements are touching, and their conduction is modeled
Conduction
Conduction
Conduction


• Each of the 4 tanks conducts to a lump of non-flowing fluid
Conduction
X
Y
Z



Temperature [F], Time = 5 hr

Panel B Heating\casePanelBheating.sav

Exchanging Temperatures -- **Tank**