

## TEAM #20 – Andromeda 3

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**Objective:** To test the feasibility of throttling solid fuel via extrusion in a hybrid rocket engine

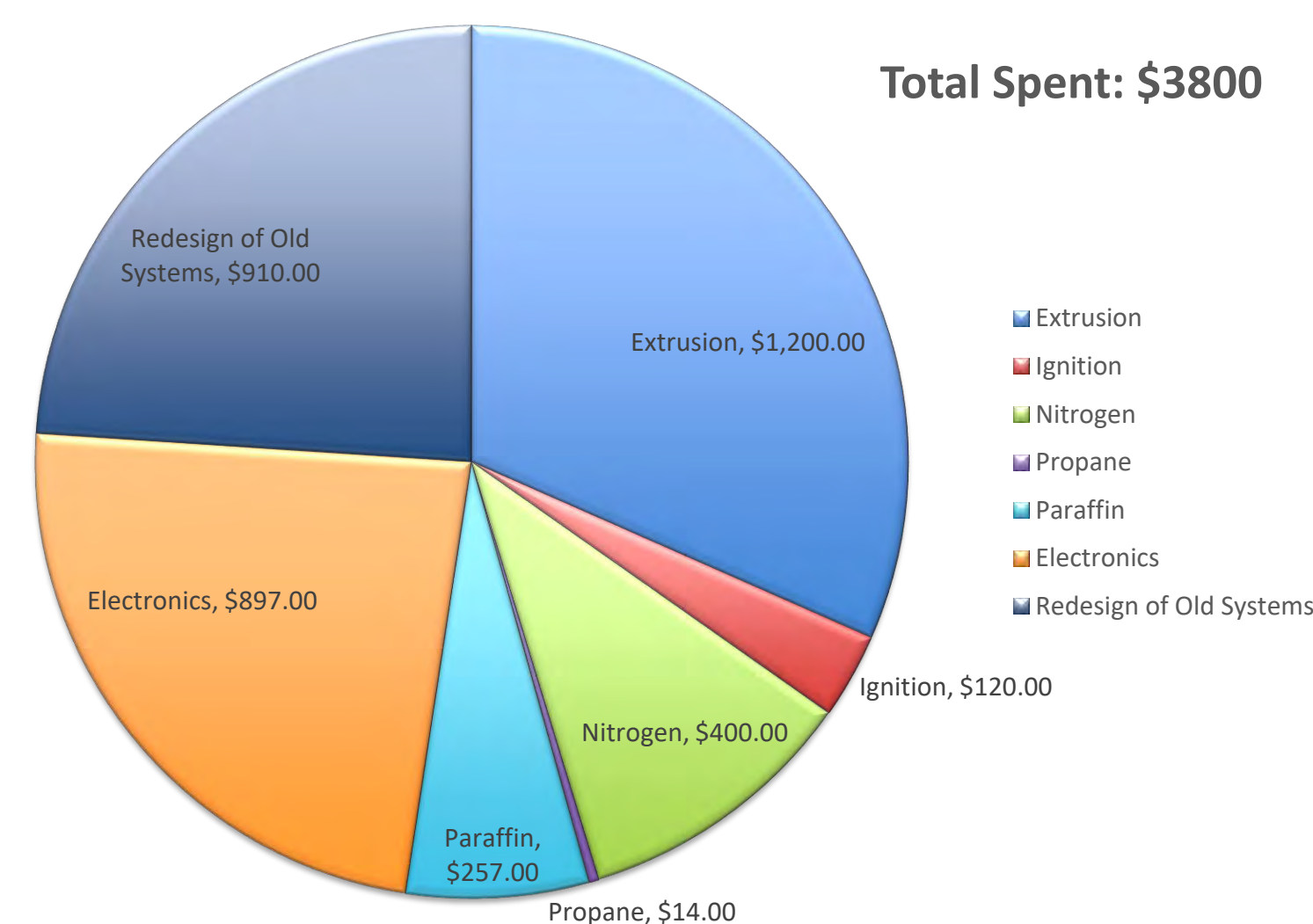
### Corporate Sponsors:



### Engineering Specifications:

Specification:	Target
Thrust (lbf)	150
Maximum Paraffin Extrusion Force (lbf)	6300
Combustion Chamber Pressure (psia)	500
Paraffin Melting Temperature (°F)	180
# of Failure/Safety Modes	2
# of visible imperfections in casted paraffin	0
Burn and Ignition time (s)	10

### \$5000 Budget Analysis:



### Complete Assembly:



### Materials Selection:

Combustion Chamber	316 Stainless Steel
Nozzle	Graphite
Extrusion Beveled Flange	Carbon Steel
Test Stand	Carbon Steel
Paraffin	1216 Embed Wax

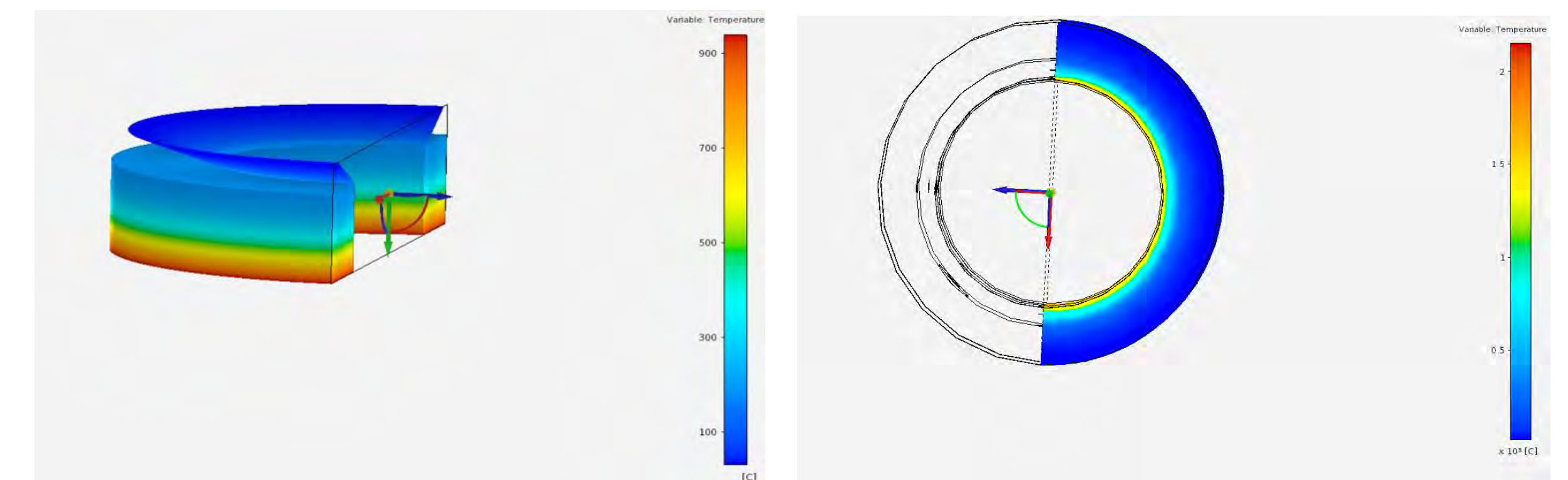
### Measurables:

- Temperature within the combustion chamber
  - Thermocouple wire (measured at 170°F during iteration 2)
- Pressure within the combustion chamber
  - Pressure transducer
- Motor Speed and paraffin regression rate
  - Feedback sensors (speed set to 25% PWM during iteration 2)
- Thrust
  - Load cell

### Testing:

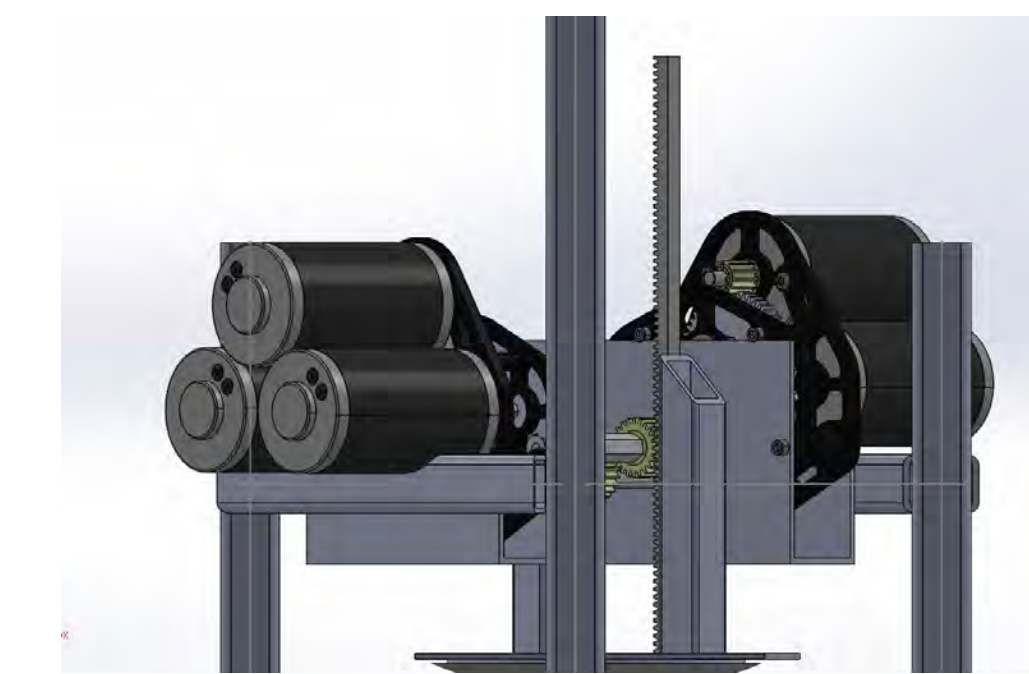
Iteration	Corrective Action Plan
1	Improve grounding wires Add bracings on extrusion members
2	Reconfigure propane fitting to improve air/fuel mixture Direct propane towards paraffin to increase heat and begin combustion

### Heat Transfer Analysis:



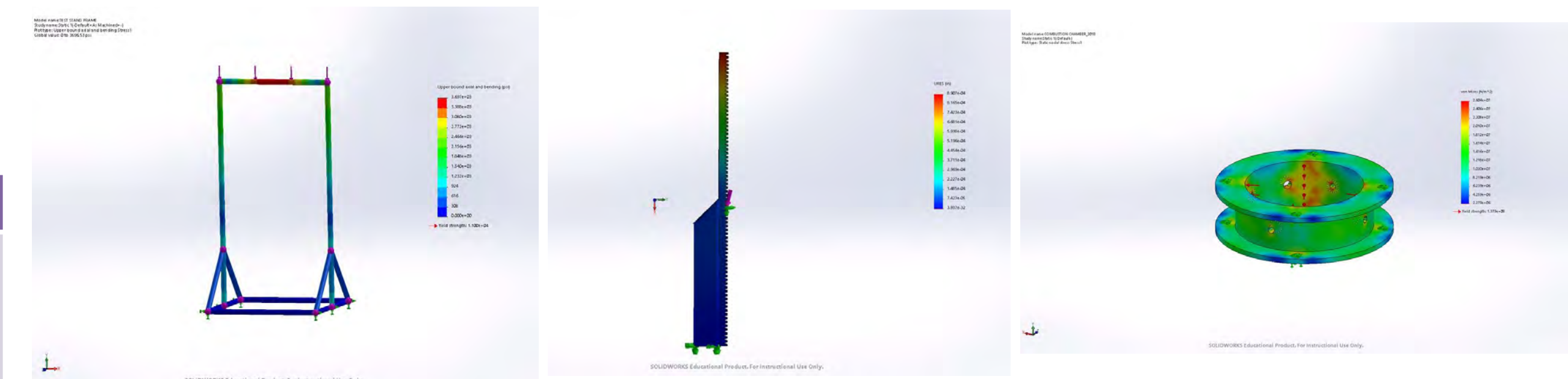
**Results:** Paraffin will melt at the base of the extrusion flange and remain solid where open to atmosphere. The combustion chamber sees rapid cooling through the 0.5" thickness and refractory material.

### Extrusion Motor Specifications:



- 3150 lbf supply required by each motor assembly
- Output Gear Radius: 0.55 in.
- Input Torque: 0.22 ft-lb per motor
- 144 ft-lb required torque
- 214:1 torque increase
- Motors operating near maximum efficiency point

### Static Loading Analysis:



**Results:** Test stand maximum deflection will occur at the location of the load cell. Extrusion member deflection is mitigated by welded tubing support. Combustion chamber temperature and static stresses are maximum at oxidizer ports. All results were checked for convergence.

August  
Research

September  
Ideation

October  
Design

November  
Analysis

December  
Procurement

January  
Procurement

February  
Fabrication

March  
Subsystem  
Testing

April  
Final Testing

May  
Presentation