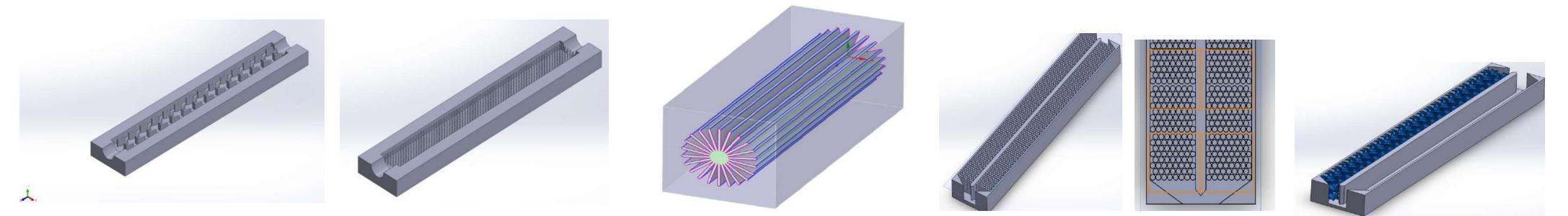
# **Additively Manufactured Cold Plate**

#### **Project Description:**

Working with Lockheed Martin, our team will design, test, and determine the best way to produce an additively manufactured (3D printed) cold plate to be used in various applications for the company's numerous radar electronics. Components such as the FCBGA microelectronics are one of the primary sources of heat that must be diffused and thus will require a cold plate. The new cold plate should be designed to meet the needs of diminishing cost, monitor the amount of material used, and improve the current heat transfer efficiency. This is a critical design because products of Lockheed Martin's can reach temperatures up to 1KW/cm<sup>2</sup>. Furthermore, an effective cold plate must be prepared to dissipate this heat from the part. Our team is looking at numerous designs with **complex** geometric flow paths to be made. Additionally, the appropriate material is to be determined for manufacturing the cold plate while considering cost and functionality.

#### **Reference Physical Problem: Avionics Module** Additive Cold Plate Design Requirements **Outlet Conditions:** Pressure: 0 psig Additive Cold Physical: Extents: 1.5 x 8 x TBD in3 Plate Segmer Scalability: Laterally Volume: Minimize Cost: Minimize Thermal Interface: Heat Flux (q"): TBD W/cm2 *Temperature:* ≤ 85°C Differential Pressure: **Objective:** Minimize **ΔP: <** 10 psid 2 x 8 array of ~15 x 20 mm2 Arrayed 🗲 interface temperature. **Objective**: Minimize ΔP FCBGA packages Laterally to maximize COP. N Times $(COP = |q| \div [\Delta P \times Vd])$ Additive Cold Plate mal Interface Material (TIM) Assume all FCBGA heat diffuses through TIM into the **FCBGA** Lockheed Martin additive cold plate (all other Inlet Conditions: surfaces are adiabatic) into PCB Coolant: PAO AN/TPQ-53 Radar System imprinted boundary patches. ~8' Flow Rate: TBD lbm/min (15 °C ~8" ~1.5" bulk temperature rise in-to-out) X-Y View Y-Z View X-Y View Inlet Temp: 60 °C ~1.5"

## **Design Options:**

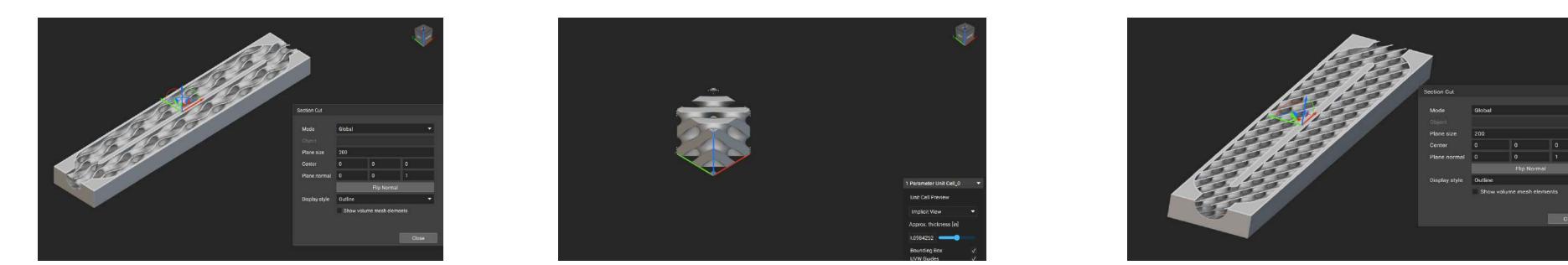


Design Option 1: Angled Fin Design

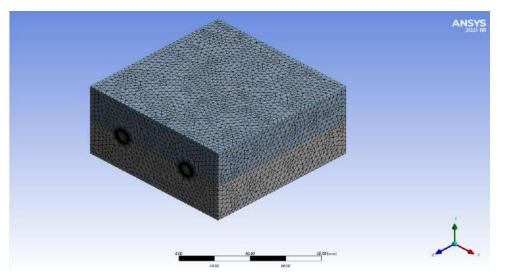
Design Option 2: 0.040" Diameter Pin Design Design Option 3: 23 spoke 0.035" Wide Star Design Design Option 4: Staggered Pin Alignment (0.07" Diameter) Design Option 5: Gyroid Pattern in Cold Plate Channel

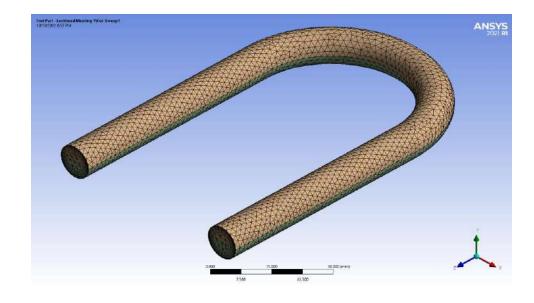
# **NTopology CAD Program:**

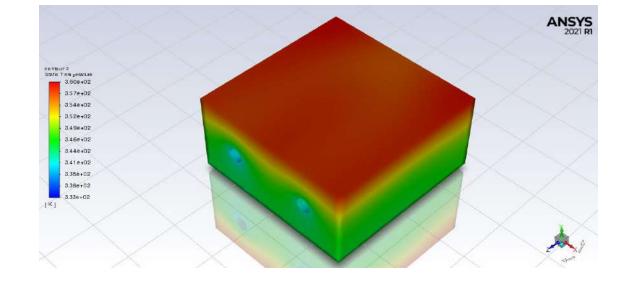
In initial research for this project, the team found a new CAD program called **NTopology** that has been used in many other additively manufactured designs. This program behaves much differently compared to other CAD programs like **SOLIDWORKS** and **ANSYS Spaceclaim**. This program uses equations to define cad bodies and lattices to aid in creating complex geometries and to allow ease of iterating designs. With that said, there is a very steep learning curve to using the program and creating an initial part, but once created the part can be manipulated with ease to allow for better analysis and for an overall better part design. Below are some of the capabilities and features that the team has designed with NTopology.

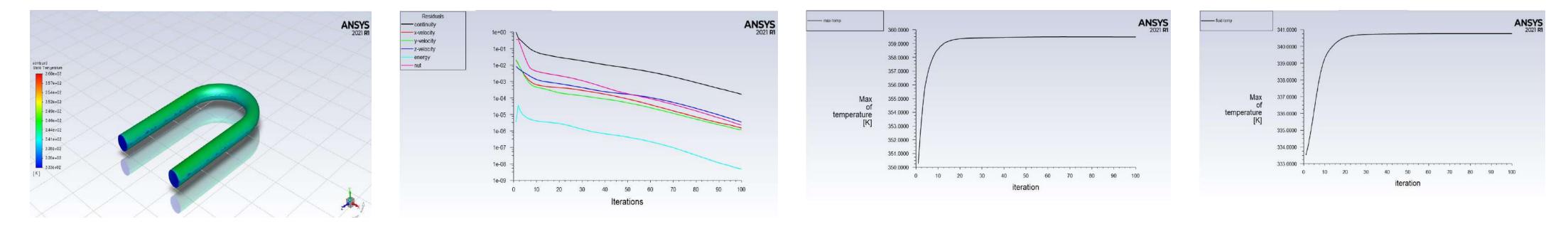


### **ANSYS Test Simulations:**









#### **Deliverables:**

- Produce an additively manufactured cold plate with dimensions of 1.5 in x 8 in
- Decrease the cost to produce as well as minimize the volume of material used while remaining within the boundary conditions
- Responsible for modeling, analysis, and production of the product
- Perform preliminary design review as well as critical design review for Lockheed Martin



Mr. Daniel Greene



Mr. Ryan Melick







Mr. Nathan Woodby



Faculty Mentor: Prof. John F. Dannenhoffer III



Mr. Benjamin Dukes



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