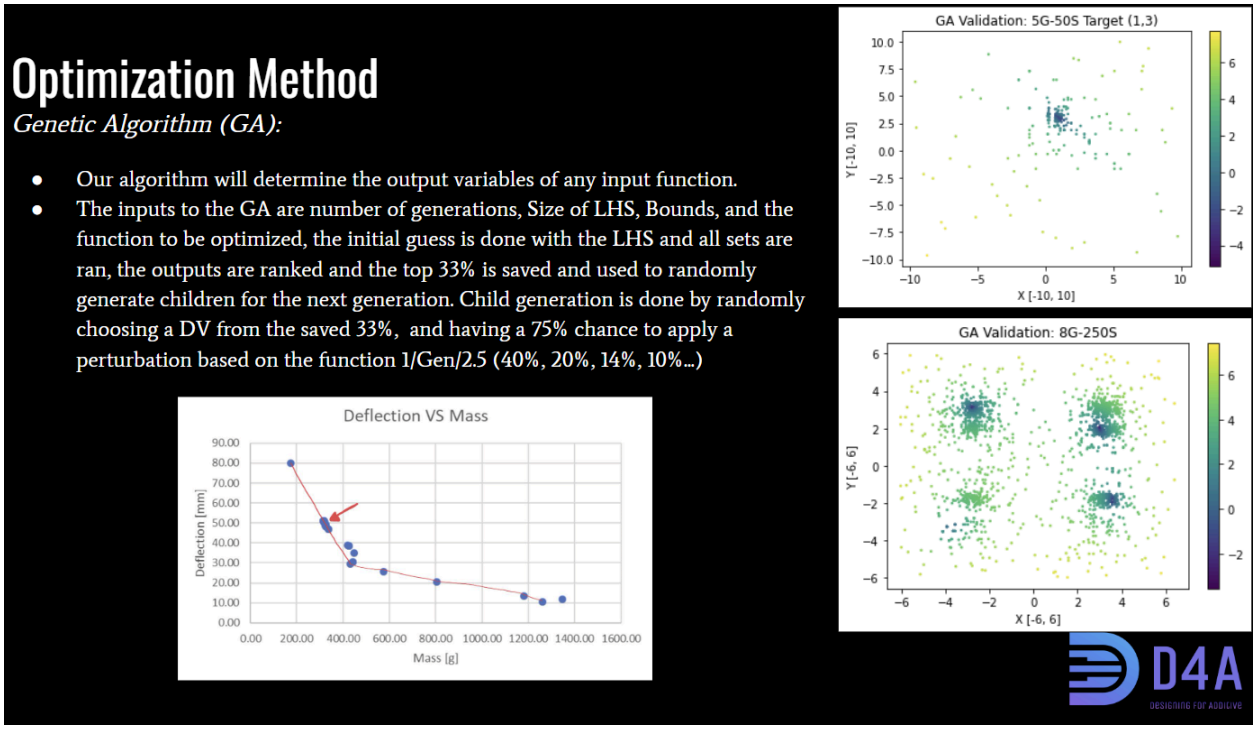
ABAQUS Spitfire Wing - Senior Elective Project Design of Experiments (DOE)

Design an experiment with multiple design variables, output variables and constraints. Use an optimization algorithm (genetic algorithm was chosen) that will automatically change the design parameters, then automatically run a new simulation in ABAQUS, then output variables of interest to inform the algorithm how to tweak the design and create the next generation for the genetic algorithm to run. The optimization was given by the objective cost function incorporating mass, and two cases for deflection high G turn and hard landing.

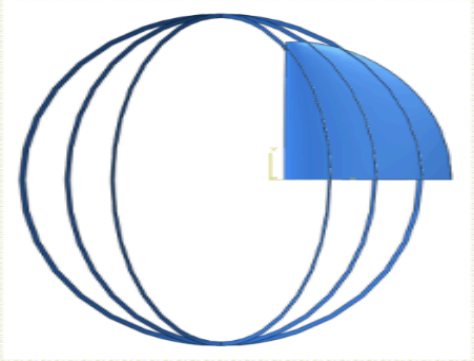


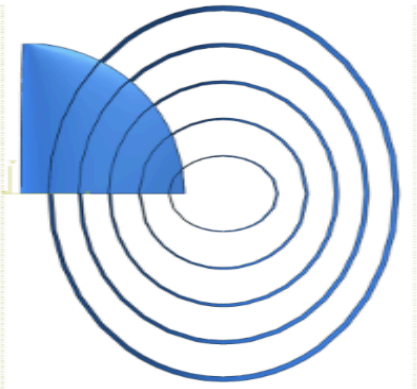
The original idea was formed because the Supermarine Spitfire aircraft from WWII were known for their elliptical, very efficient wing, which was also known for being difficult to

manufacture. The question was posed, “what if the difficulty of manufacturing is completely uncoupled with a design’s shape?” which of course implies application of additive manufacturing or 3D printing. 3D printing does not care how weirdly shaped your wing is, it instead cares about other things, like overhang angle, which constrains the problem.

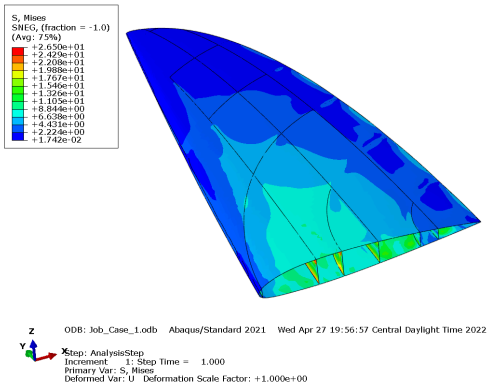
The path for this project was built with the intention to eliminate big mistakes overlooked as early as possible using proper DOE methods. The fastest method is independently testing many potential design variables with your intended measured outputs at the minimum and maximums of your design constraints to verify which of the predicted design variables are important and which ones are not worth the computing power to simulate. This enabled us to eliminate 2 design variables saving valuable time and compute.

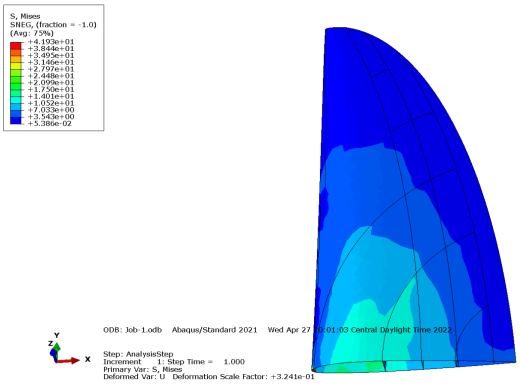
The experiment was built with the idea of the wing’s ribs and spars combining into a single concept called ‘spibs’, created from ellipses, with their thickness, shape, and quantity being design variables in the DOE, shown below.





Examples of the final result:





Full report:

3D printed wing Final Report.pdf