

AAE 334 Fall 2016 Extra Credit Project

Due Friday, December 2, 2016
Please submit your report through Blackboard

In the Marvel Avengers movies, the S.H.I.E.L.D. Helicarrier (pictured below) is a kind of flying aircraft carrier. It can sail on the ocean like a conventional ship, but can also lift out of the water and fly.



Image from the movie The Avengers (Marvel Studios, 2012)

Lift for the Helicarrier is provided by four fans, and forward propulsion is provided by two arrays of jet engines in the rear. The fans appear to each have a diameter about 50 m, and the overall size of the vehicle seems similar to a conventional aircraft carrier. For comparison, a United States Nimitz-class aircraft carrier has a length of about 330 m, mass of about 1.0×10^8 kg (10^5 metric tons), and is powered by two Westinghouse A4W nuclear reactors, which can produce about 200 MW each.

Your challenge is to analyze the operation of the Helicarrier. Research rotary wing aerodynamics, and determine how much force the four fans could produce. How fast do they have to spin? Are compressibility effects important? (Note that there are problems with supersonic propeller tip speeds; look up the XF-84H test aircraft.) Make an estimate of the lift provided by the body of the vessel in forward flight. Make a plot of the power required to lift the Helicarrier, as a function of altitude and forward speed. What range of forward speed is possible? You could also consider stability and jet fuel consumption.

Although it's hard to find flaw in this beautiful concept, it's possibly unrealistic. How would you redesign it? What benefit does the flying aircraft carrier provide the customer (S.H.I.E.L.D.), and how could you achieve that with an alternative design? Justify your arguments with quantitative estimates. Try to estimate the relative cost of alternative designs.

This is an open-ended project; there is no single, correct answer. Be as creative as you want, but you have to justify all your assertions. Choose reasonable approximations to make the calculations feasible. The report should include at least the following:

- Estimate of the maximum force produced by the fans and their maximum rotation rate
- Plot of power required versus altitude and forward speed
- Consideration of an alternative design

You are encouraged to go further into the analysis.

Write a short report on your project, typed, and about 5 pages double spaced, including figures and equations. Explain your assumptions. Use whatever resources you can find, but include references to all of them in your report. Use a consistent style for the references (see: <https://owl.english.purdue.edu/owl/section/2/>). You are free to work together, but each student must write and hand in an individual report. List all your collaborators at the end of your report. This optional extra credit project will be worth up to the equivalent of 15 points (3 letter grades) on the midterm. Credit will depend on innovation, level of effort, and quality of the report.

There are some more stills from the movies showing the Helicarrier here:

http://marvel-movies.wikia.com/wiki/S.H.I.E.L.D._Helicarrier?file=Helicarrier_rises.jpg