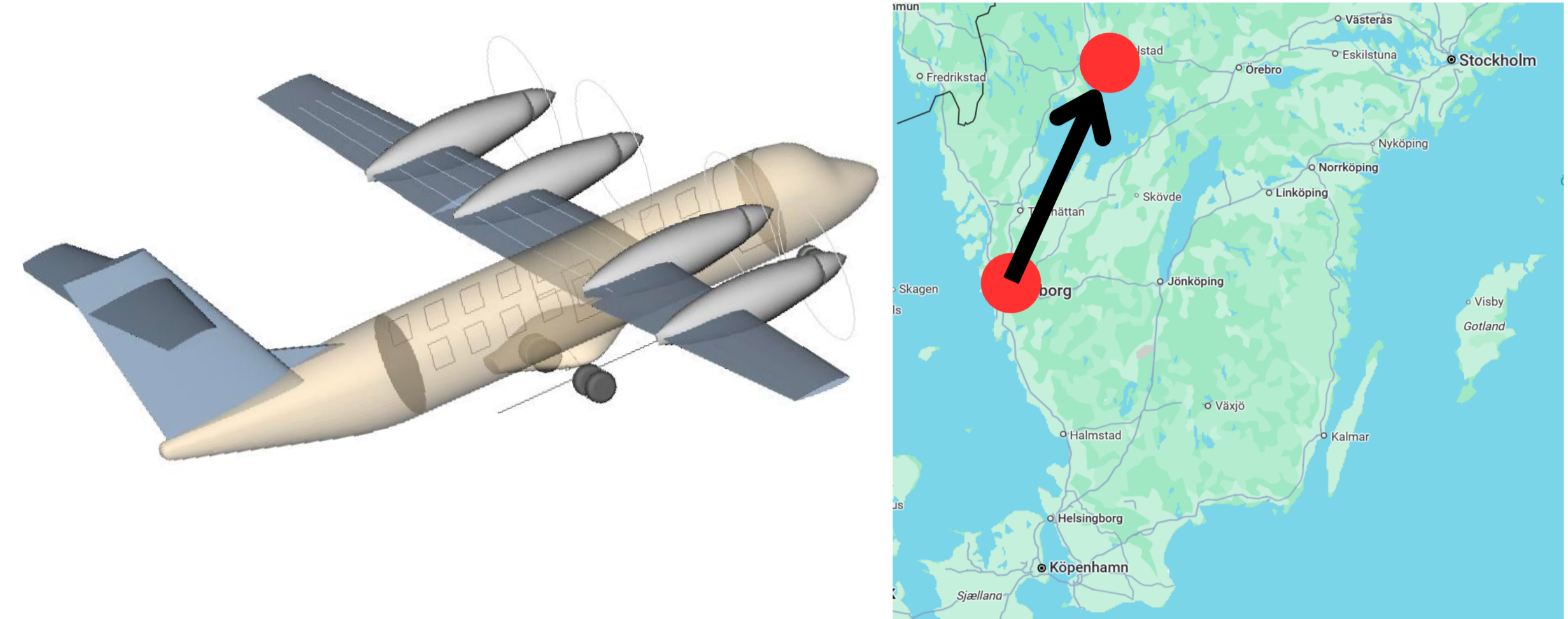


### Project Description and Aim

This project investigates whether readily available fuel cell technology can access Karlstad from Gothenburg, a distance of 206 km, and how far it is possible to travel within the plane's weight limits.



### Facts About the Airplane

- Maximum takeoff weight: 8618 kg
- Maximum fuel cell, fuel and tank weight 2400kg
- Passengers: 19 passengers á 95kg
- Max power 1300 kW (takeoff)
- Cruise speed: 340km/h

### Theory & Methodology

The power required to propel the plane depends on alpha, the angle of attack of the airflow hitting the plane. Alpha, in turn, depends on several parameters, such as lift and drag, which themselves vary with alpha. An iterative process is used to determine alpha at each altitude, after which the force is calculated, followed by the power. All of this is done using the flight equations and other relevant equations.

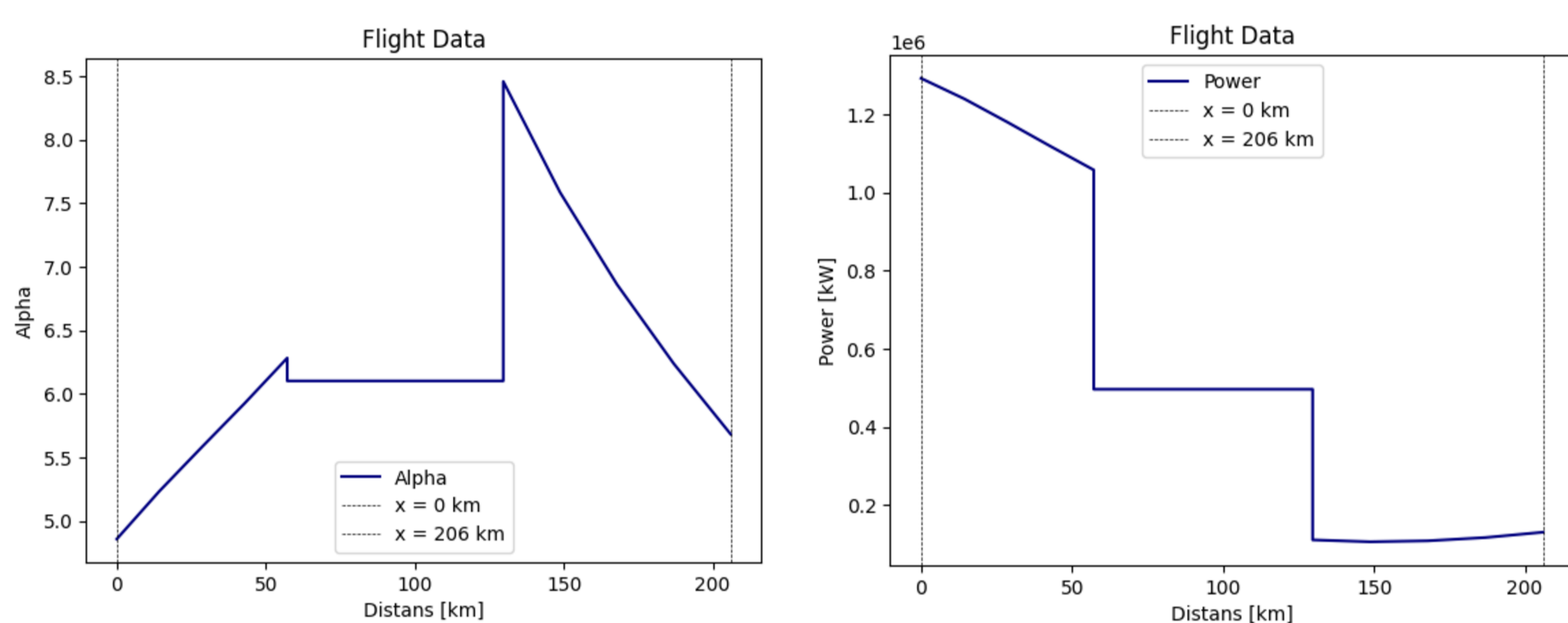
### Flight Mechanic Equations

$$0 = -L \cdot \sin(y) - D \cdot \cos(y) + F \cdot \cos(\alpha + y)$$

$$0 = L \cdot \cos(y) - D \cdot \sin(y) + F \cdot \sin(\alpha + y) - mg$$

### Assumptions About the Flight

- Power and electrical motor efficiency: 85%
- Fuel cell efficiency: 45%
- +200 kW in max power in case of bad weather
- Hydrogen reserve to fly an extra 70 km



Flight data for Göteborg-Karlstad including power and angle of attack

### Weight of Fuel Cell and Tank (with fuel)

- The power density is assumed to be  $p = 0.5 \text{ kW/kg}$  and  $p = 1.5 \text{ kW/kg}$ , respectively.
- LHV = 120 MJ/kg, and the tank is assumed to have double the weight of the hydrogen.
- $m_{fc} = P_{max}/p$
- $m_{tank} = 3(P \cdot t / LHV)$

### Results and Conclusion

According to the calculations, it is possible to fly to Karlstad with a fuel-cell-powered airplane. As the airplane had a significant weight margin, further studies were conducted to investigate the aircraft's maximum range.

### Existing Systems

- Power density 0.5 kW/kg
- Fuel cell weight 3175 kg
- Cryogenic tank 100 kg
- Fuel weight 50 kg
- Possible travel distance 360 km

### Theoretical Values

- Power density 1.5 kW/kg
- Fuel cell weight 880kg
- Cryogenic tank 919 kg
- Hydrogen fuel weight 459 kg
- Possible travel distance 3990 km

