



## INTRODUCTION

- In 2007, Wright B Flyer Inc. manufactured a flying replica of the Wright Model B known as the Silver Bird
- Awarded an FAA airworthiness certification in the Fall of 2010
- In June 2011, after about 20 hours of flight time, the aircraft was lost in a crash during a test flight
- A welding malfunction caused a failure in one of the propeller shafts, rendering one of the props essentially useless
- The tragic occurrence resulted in the death of two pilots
- Wright B Flyer Inc. has commissioned another Silver Bird model to be designed and produced with goals of improved safety and better performance

## PROBLEM STATEMENT

Model the Wright B Flyer Inc. Silver Bird in the Merlin flight simulator to attain the flight characteristics of the actual Silver Bird and to produce design sensitivities to improve the performance of the aircraft.

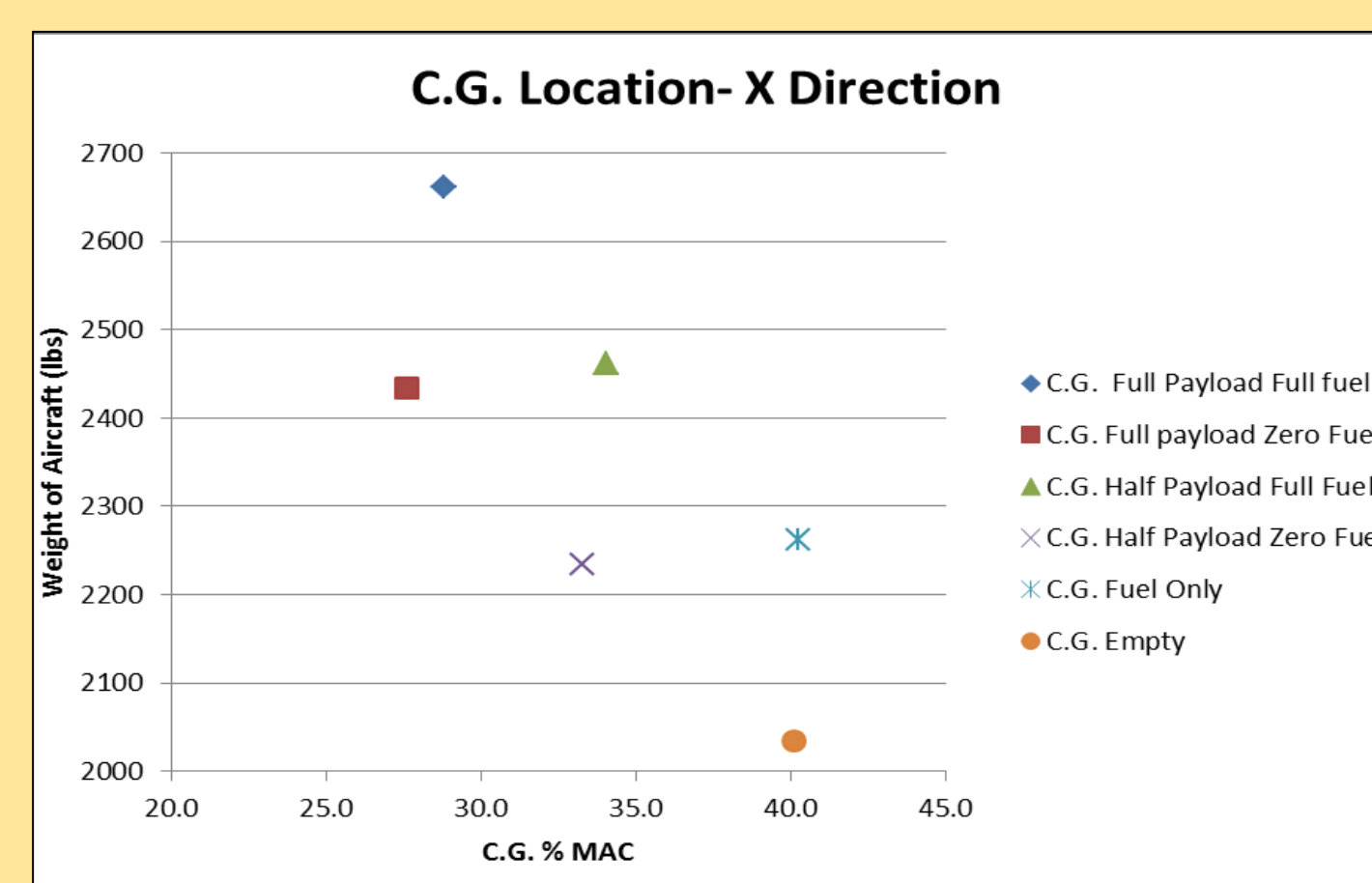
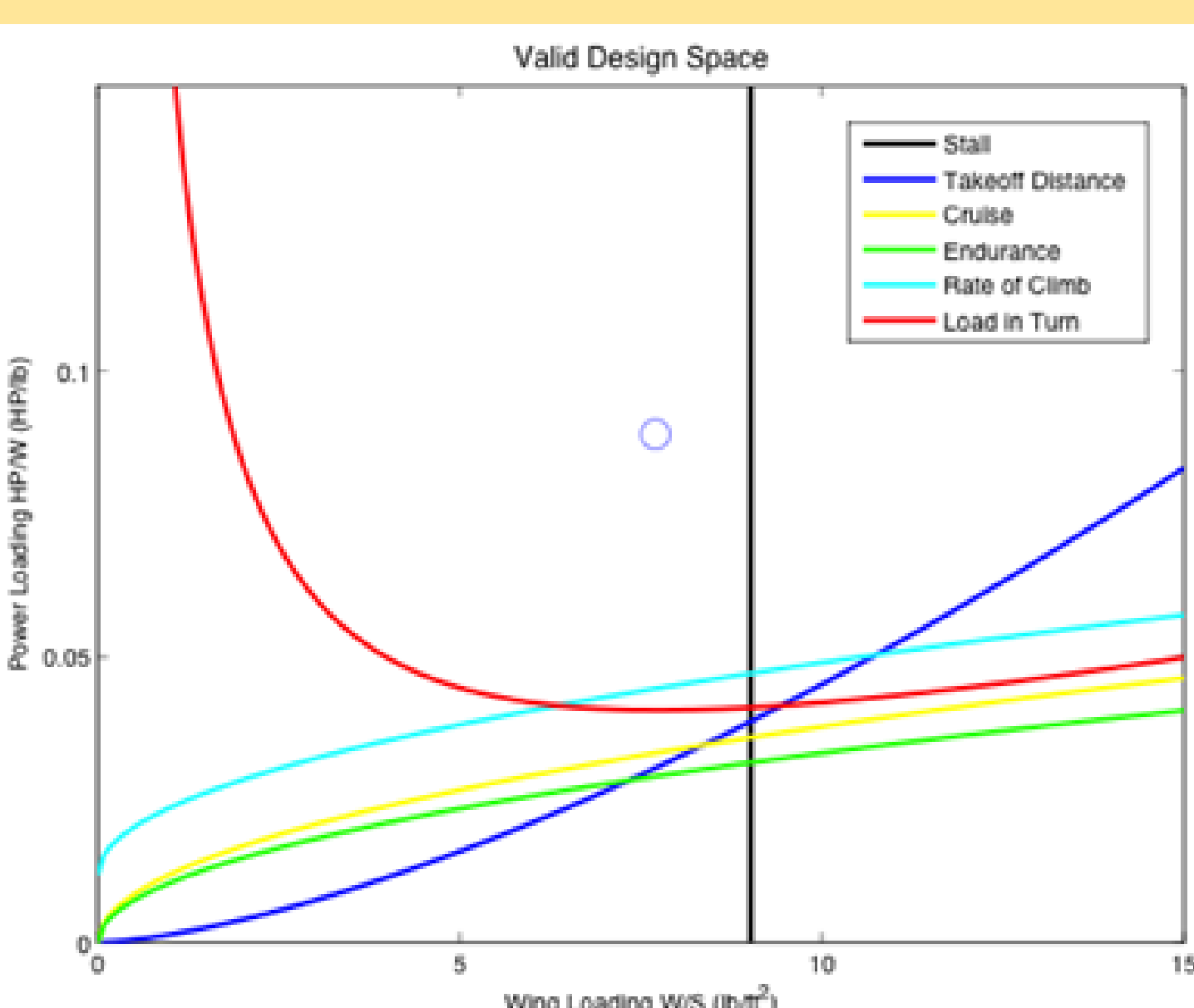
## SIMULATOR BACKGROUND

Acquired in 2011 by the University of Dayton, the Merlin flight simulator is an engineering simulator that allows students to model and fly designed aircraft. The simulator is just one of 15 in the world and the only one in the United States.

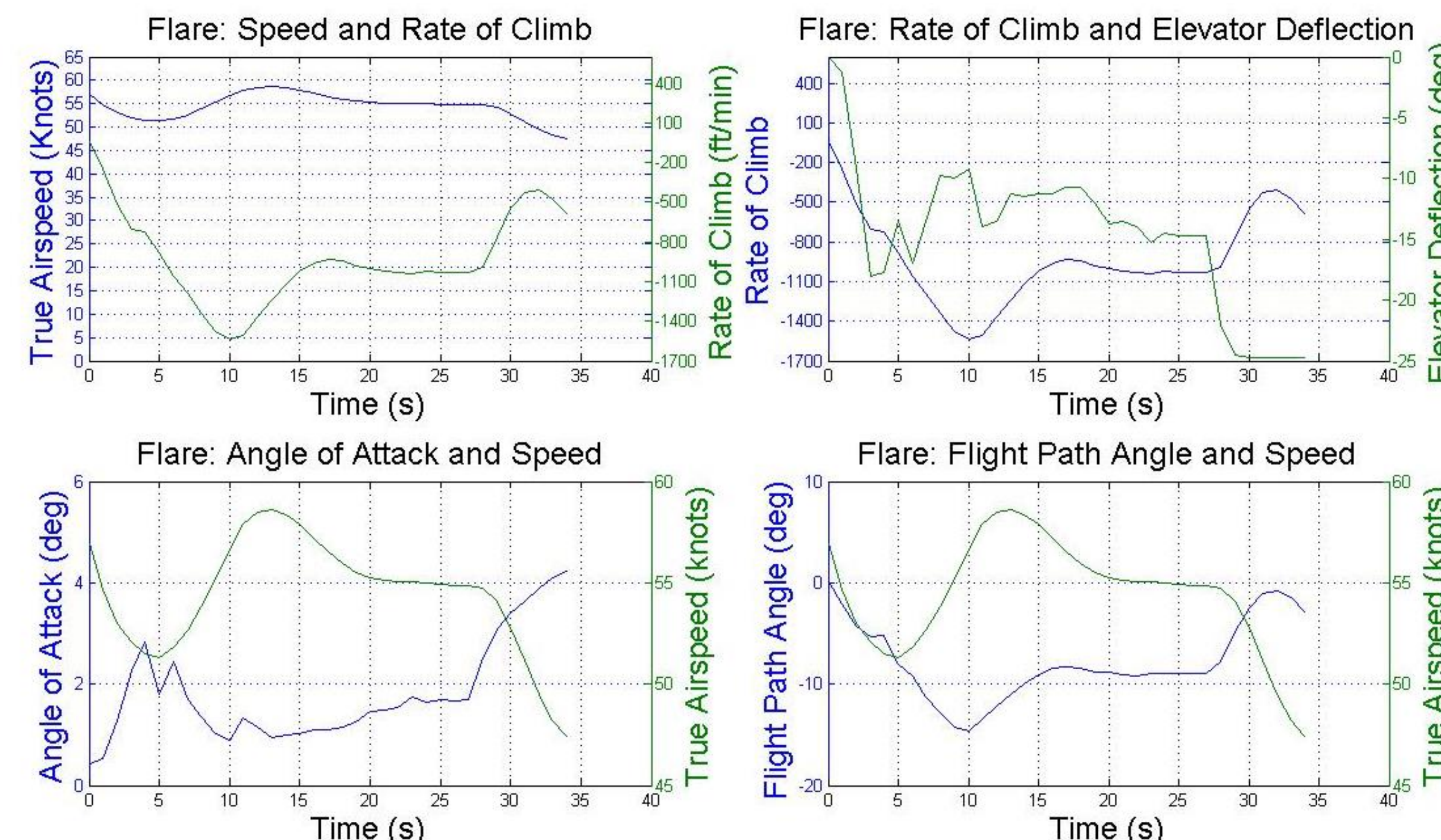


## CONCEPTUAL DESIGN PROCESS

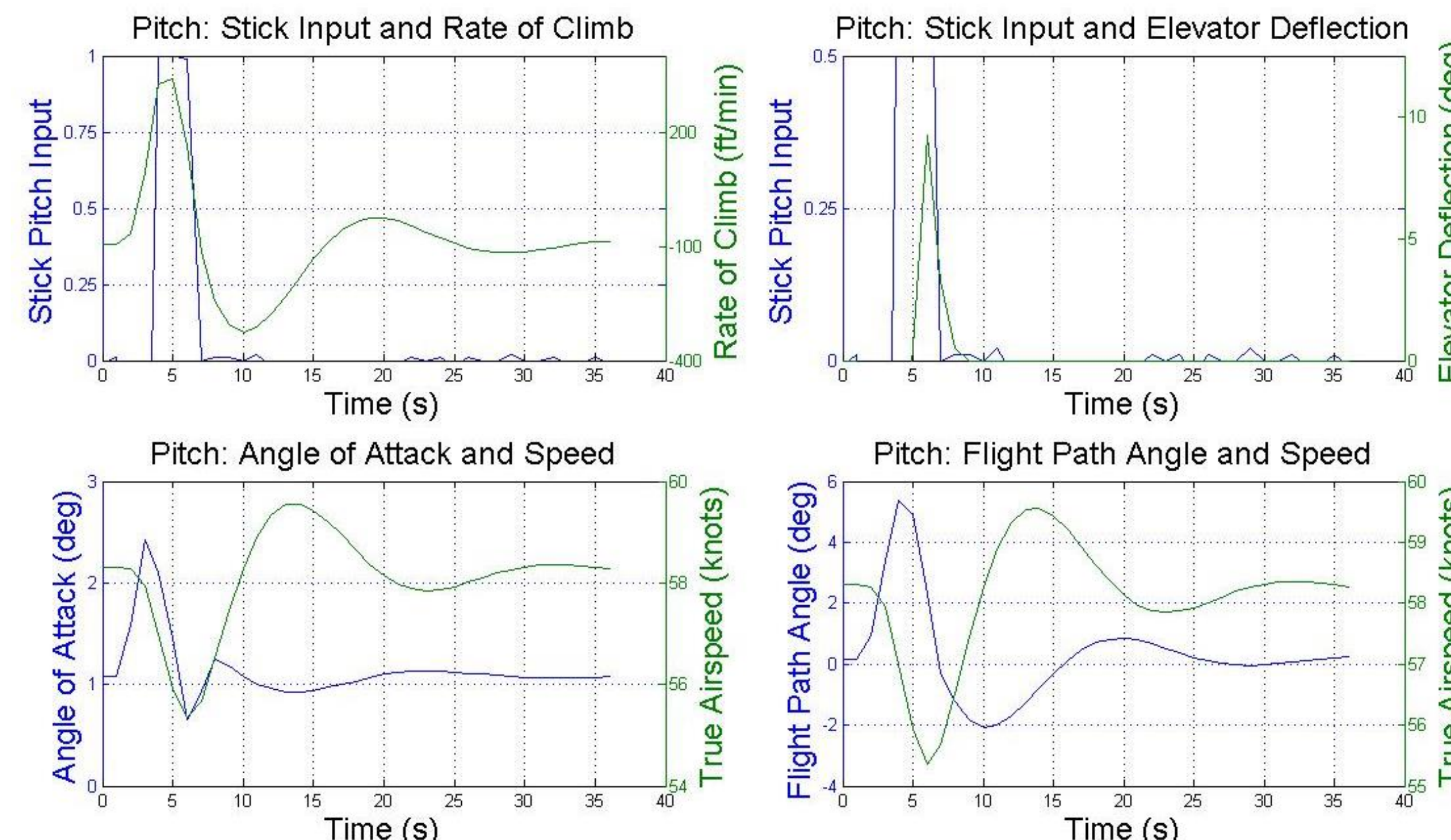
- The valid design space was determined from the various flight performance constraints of the model (stall, rate of climb, load in level turn, takeoff) given flight test data obtained from the original Silver Bird.
- A request for proposal was given to the Senior Design Team from Wright B Flyer Inc. to develop an accurate model of the Silver Bird and to evaluate changes in design parameters in order to provide a safer more reliable aircraft.
- The Center of Gravity (C.G.) envelope was determined based upon multiple weight configurations as shown.
- An aerodynamic study was conducted using the XFOIL program to determine the coefficients of lift, drag, and moments of the main wing as well as the corresponding increments for the control surfaces per degree of deflection. The NACA 4412 airfoil was used based on the availability of accurate experimental data when compared to the actual USA 35-B found on the actual Silver Bird.



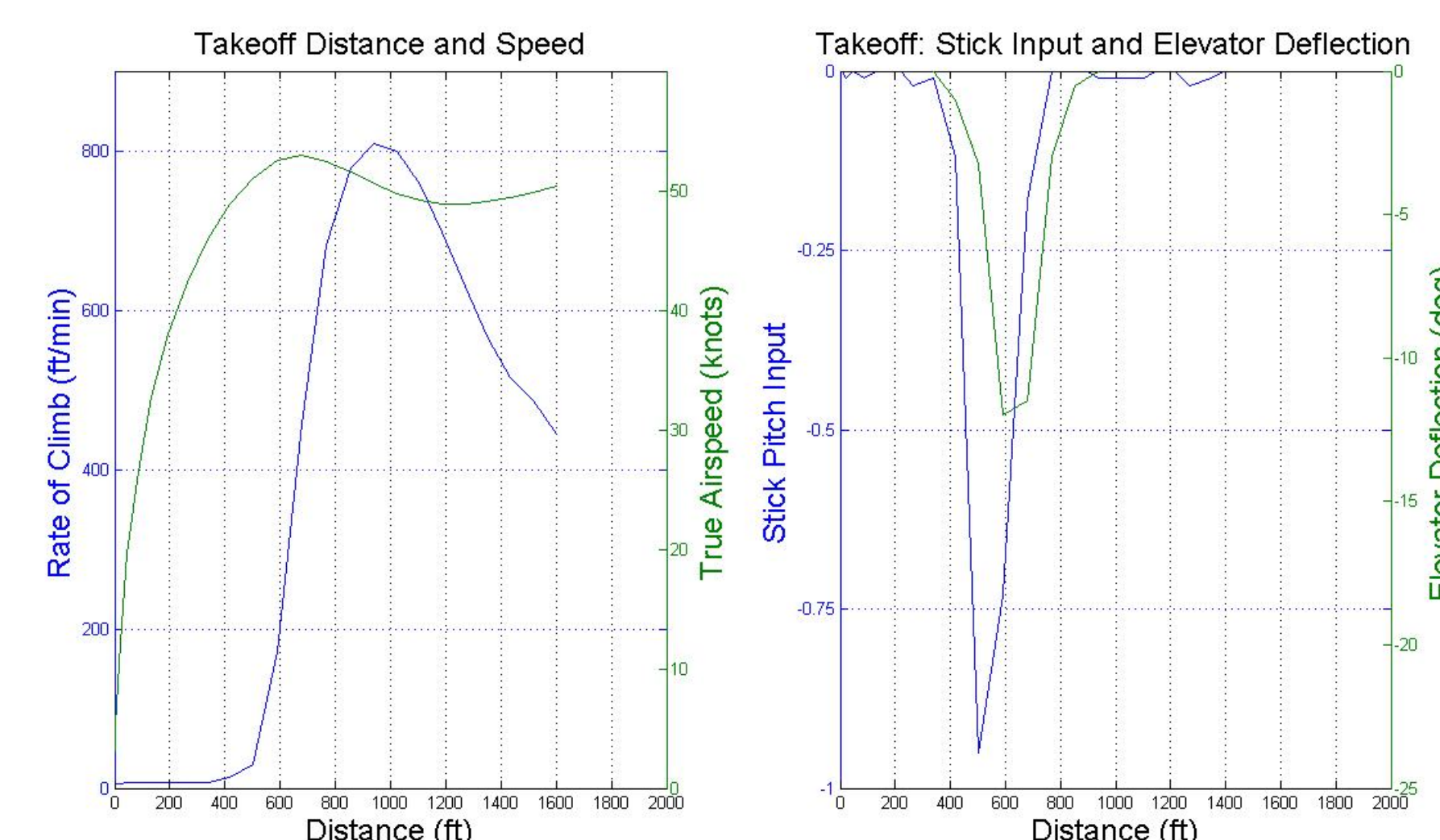
## FLIGHT DATA



- As a result of the propeller failure experienced in the Silver Bird during its crash, the elevator effectiveness (flare) during an engine out scenario was evaluated by cutting the power to both of the simulated engines and maintaining 55 knots with nose down until exhausting the available elevator input at approximately 100 feet. As seen above, with engine out conditions the available elevator travel is insufficient to allow for flare which generally greatly lessens the impact upon landing. The inability of the simulated Silver Bird to flare can be seen by the absence of a positive rate of climb before crashing.



- A pitch doublet was also simulated to evaluate the longitudinal stability of the aircraft. It can be seen above that the Silver Bird dampens in the longitudinal stability axis and returns to the nominal angle of attack.



- The rate of climb, airspeed, and elevator deflection were evaluated during takeoff. The max rate of climb at takeoff was recorded as 800 ft/min and the takeoff distance is shown as 500 feet.

## TEST PILOT FEEDBACK

Members of the Experimental Test Pilot's group, Pilot 1 and Pilot 2, volunteered their time to provide their feedback on the model given their combined 15 hours of experience flying the Silver Bird. Their comments along with the corresponding changes are given below.

- Pilot comment: Too much stick down input to achieve steady level flight  
**Team Solution:** Center of gravity was moved forward by 0.1 meters. This was justified from sensitivity of the Silver Bird to pilot's weights and ability to change this by minimal geometry manipulation.
- Pilot Comment: Rate of climb too low  
**Team Solution:** Fuselage drag was decreased in order to achieve rate of climb and cruise speed from limited flight test data from actual Silver Bird flight data.
- Pilot Comment: Roll response too high  
**Team Solution:** Decreased lift increments of the ailerons along with percent stick input per percent aileron deflection
- Pilot Comment: Lack of elevator flare in power off steady dive (55 knots)  
**Team Solution:** Increase elevator maximum positive deflection by 1 degree to account for the lack of inclusion of propwash effects in the flight simulator flight physics model. This would effectively increase the elevator's effectiveness. Also the elevator lift increment at max deflection was slightly increased.
- Pilot Comment: Throttle response too slow  
**Team Solution:** Throttle lapse rate was increased
- Pilot Comment: Trim response negligible  
**Team Solution:** Increased alpha trim range in order to be able to trim to steady level flight at cruise speed and altitude

## DESIGN IMPROVEMENTS

- Design improvements were made to the aircraft model to enhance the performance of the Silver Bird for engine out conditions and everyday flight.
- Wright B Flyer requested design changes of the rudder to be evaluated with the design changes being dual vs single rudder; increase distance between the rudders in the dual configuration, and to increase rudder deflection for the single rudder design.
- An additional design change increased the incidence angle of the main wing to generate more lift at lower angles of attack and low velocities.
- A Center of Gravity (C.G.) sensitivity study was conducted to address the inherently unstable characteristics of the Silver Bird allowing for a more stable aircraft with a more forward C.G.

## CONCLUSIONS

- Through multiple iterations, a reasonably accurate model of the Silver Bird was achieved in conjunction with the Request for Proposal that was provided by the sponsor.
- This will prompt the design and creation of the next Silver Bird model that will be a more reliable safer aircraft.
- This allowed the team to gain experience with the conceptual design process while providing a useful service to a customer.

## ACKNOWLEDGEMENTS

- Dr. Aaron Altman - University of Dayton, Advisor
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- Mr. John Hageman and Mr. Eunsung Shin - MEE 432L Professors
- Ms. Rachel Petro and Mr. Neil Capeci - Simulator Technicians