Two Space Grant Supported Perspectives on Research: A Continuous Trailing Edge Flap Design and Automated Landing Systems for Unmanned Air Vehicles

Benjamin León
Georgia Tech
GA Space Grant Consortium

Overview

- Continuous Trailing Edge Flap Design
  - Background
  - Model Design
  - Electronics
  - Tests and Results
- Automated Landing System
  - Background
  - Software in the Loop Tests
  - Hardware Interface
  - Ground Tests

Aerodynamic Characterization of a Continuous Trailing Edge Flap Design

Mentors:

Karen Taminger

Dr. Elizabeth Ward

2013 Aeronautics Academy

Travyn Mapes
Utah State University
(Mechanical and Aerospace Engineering)

Mark Agate
University of Miami
(Aerospace Engineering)

Mark Fellows
Miami University
(Computational Science and Engineering)

Jane Fleming
Fort Lewis College
(General Engineering, Mechanical Emphasis)

Joey DeCarlo
University of Minnesota
(Aerospace Engineering and Mechanics)

Sean Spillane
City College of New York
(Mechanical Engineering)

Brittney Lipp
Iowa State University
(Aerospace Engineering)

Taylor Ray
Colorado School of Mines
(Electrical Engineering)

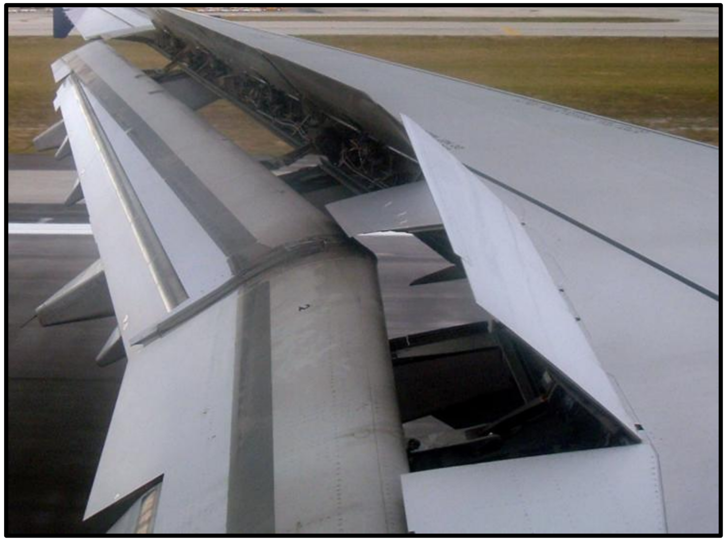
Benjamin León
Georgia Institute of Technology
(Aerospace Engineering)

Nick Harvey
University of Washington
(Aeronautics and Astronautics)

James Tennant
Wichita State University
(Aerospace Engineering)

Russell Gillespie
West Virginia Wesleyan College
(Applied Physics)

CTEF: Background



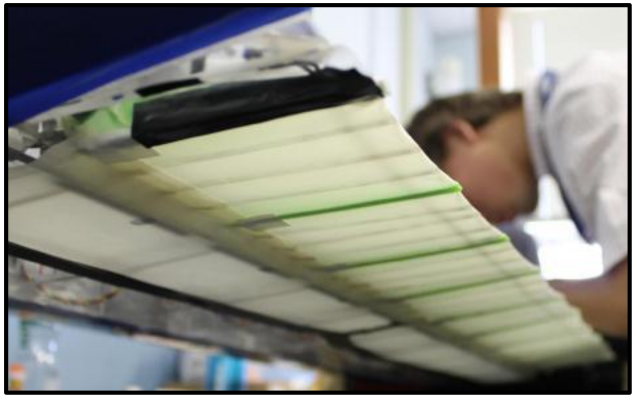
Credit: Richardgm

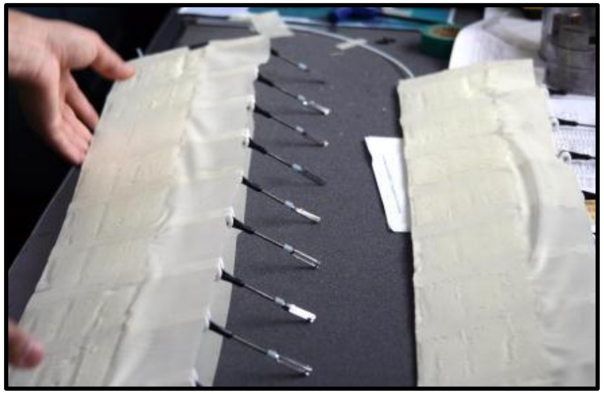
- Conventional flap design
  - Uniformly vary wing camber to alter lift and drag characteristics

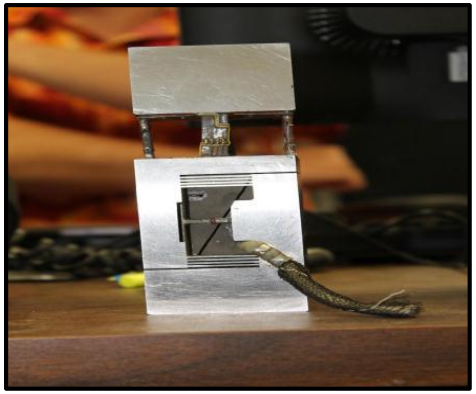
- Continuous Trailing Edge Flap design (CTEF)
  - There are no ‘breaks’ in the trailing edge
  - Camber can be varied along the span, along the chord, or a combination of both
  - N+3 technology[1]

CTEF: Wing Design

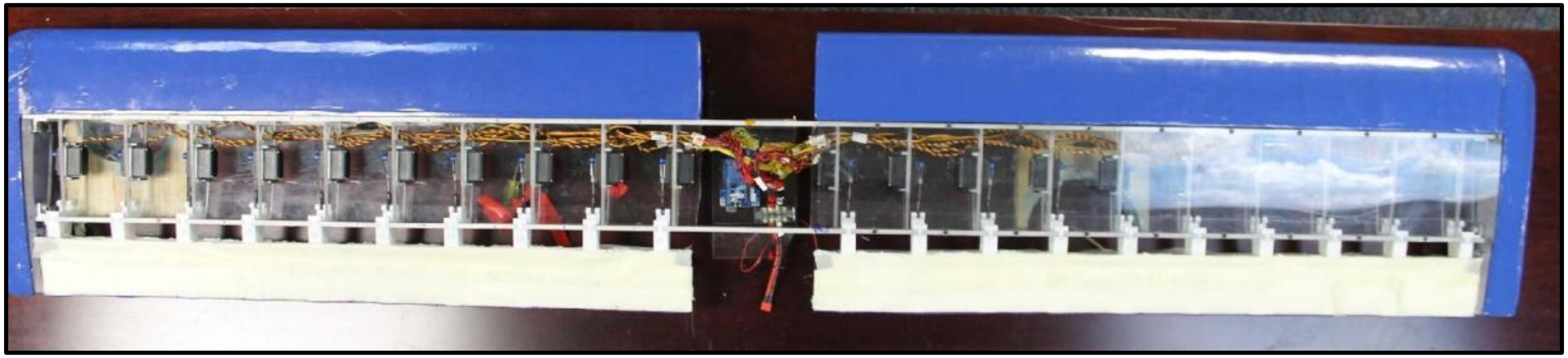
- Interchangeable control surfaces
- 6.5 ft. span maximum
- Accommodate many servos/electronic components
- High degree of stiffness
- Wind tunnel balance limits

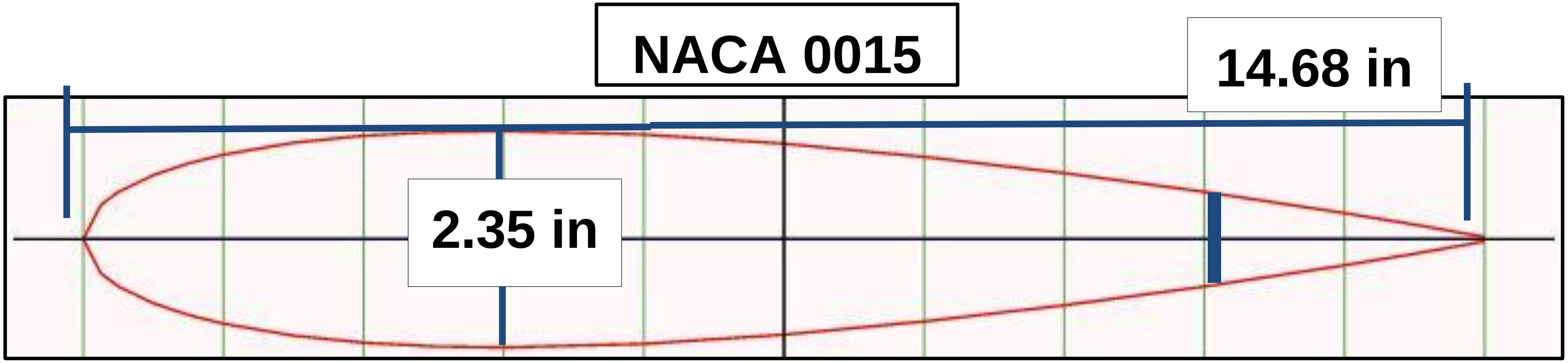






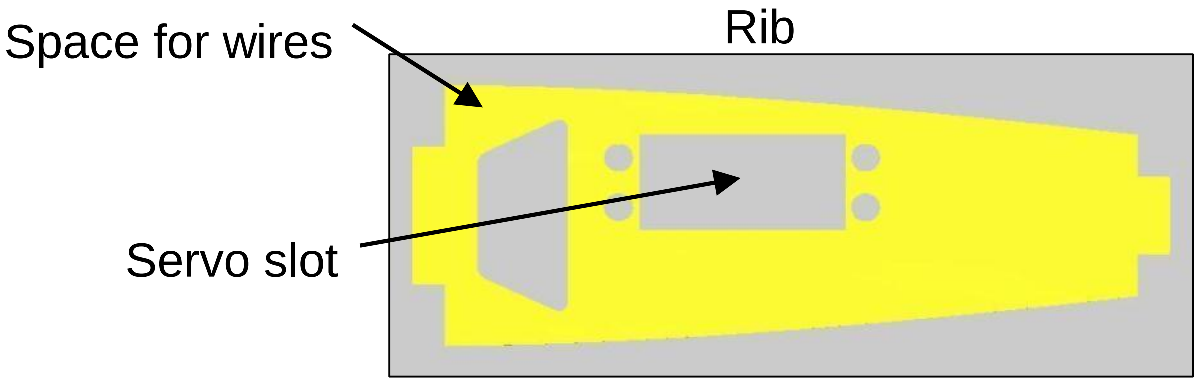
- Airfoil
- Span
- Planform/Taper

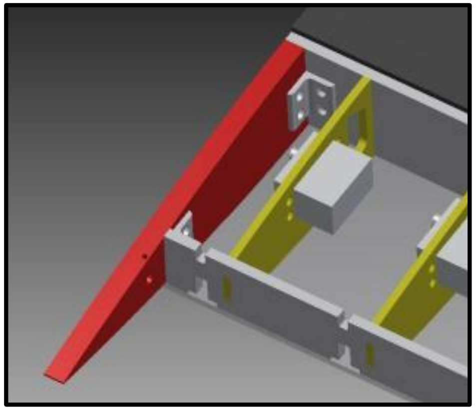


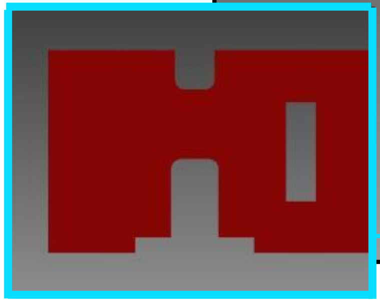


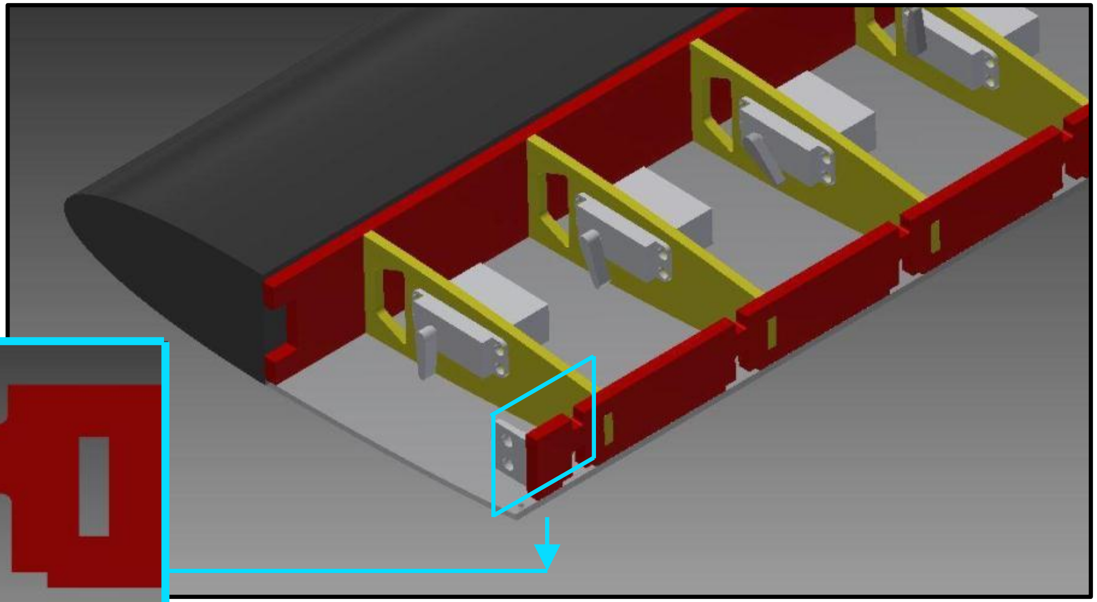
CTEF: Wing Design

- Rib shape
- Back spar compatibility
- Foam leading edge









Images produced in Autodesk Inventor

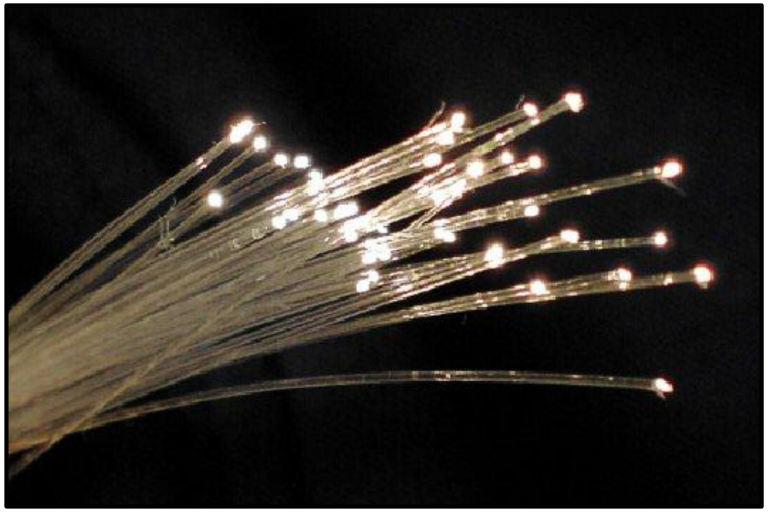
CTEF: Electronics

Hardware considerations:

- Compatibility
- Control multiple designs
- Strength of servos

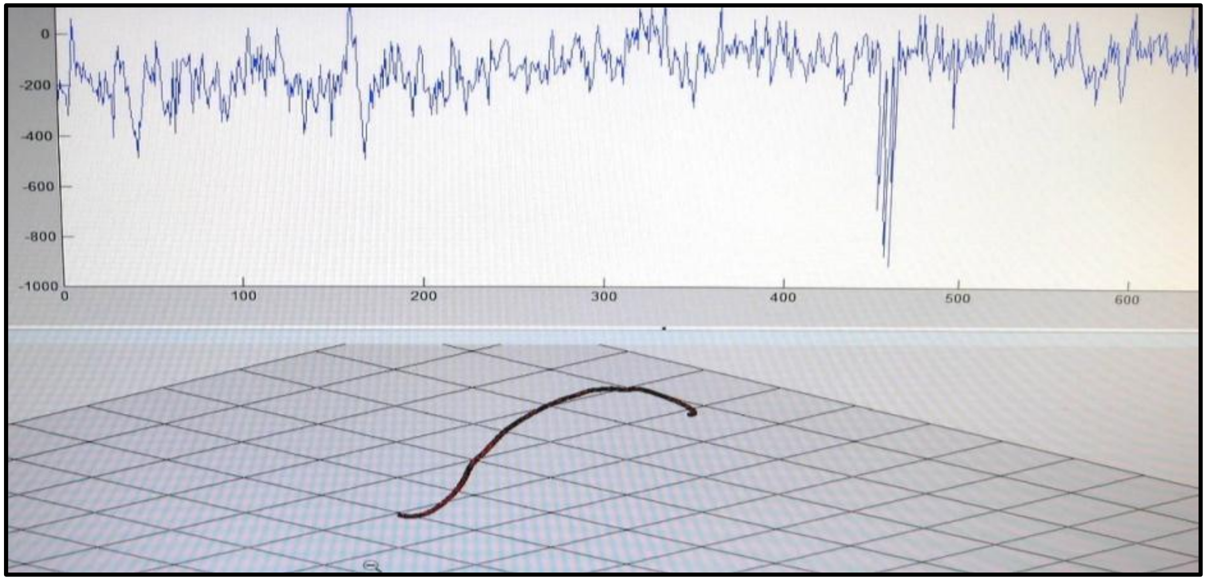
CTEF: Electronics

Credit: BigRiz



Fiber Optics

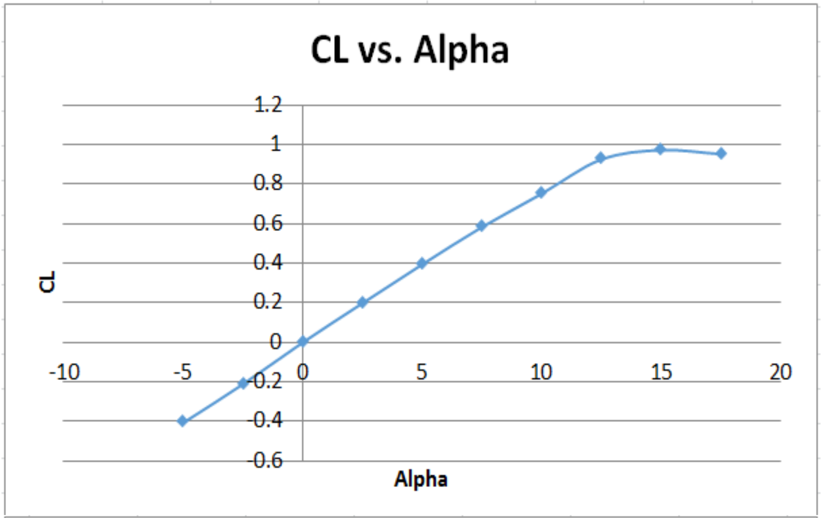
- Strain gauge sensing
- Shape sensing tri-core
- Integrate fibers into the wing and tunnel systems
- Data collection

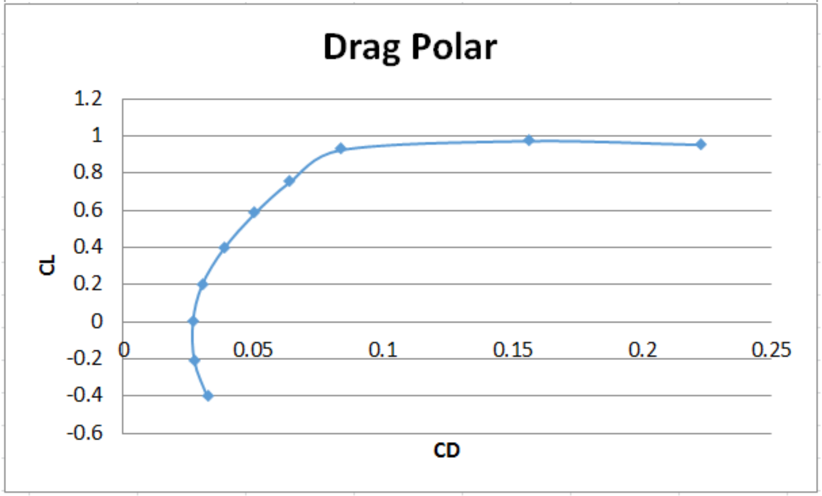


CTEF: Finger Design

CTEF: Data Analysis

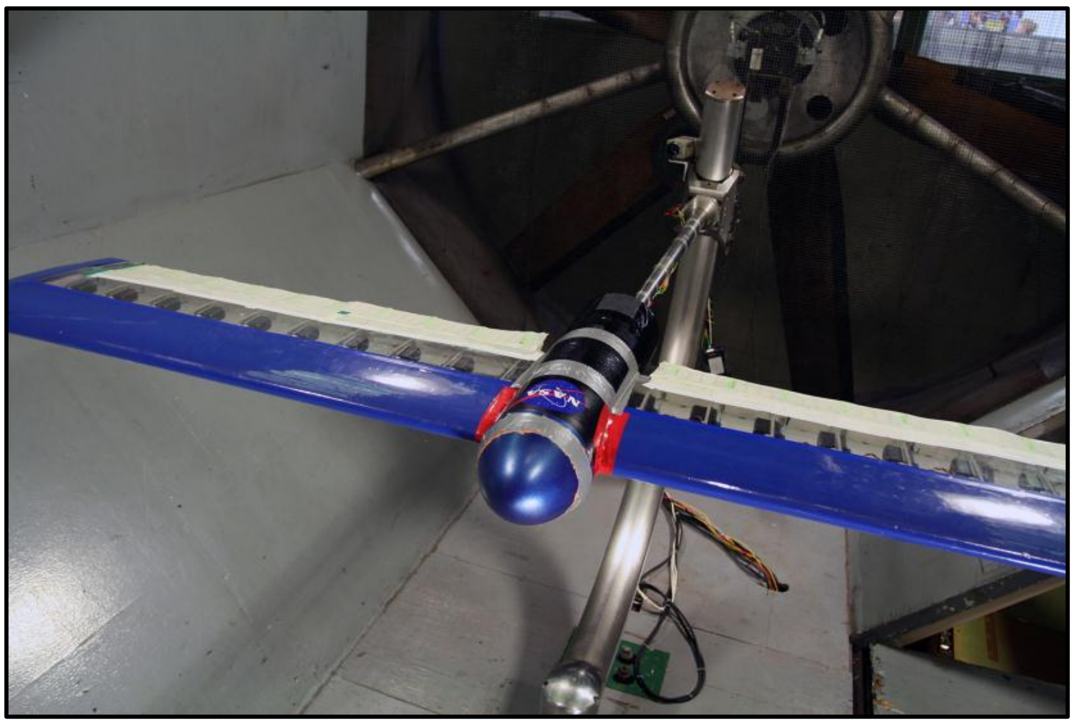
- $C_{L_{max}} = 0.927$
- $C_{D_0} = 0.025$
- Error: $\pm$9.56% at 95% confidence interval
- NACA0015
  - $0.9 < C_{l_{max}} < 1.4$[4]
  - $0.005 < C_{d_0} < 0.03$[4]





CTEF: Research Outcomes

- Design and build objectives met
  - Conventional flap/aileron test as control
- Two and a half days of successful wind tunnel testing



Development and Integration of Automated Landing Systems for Unmanned Air Vehicles

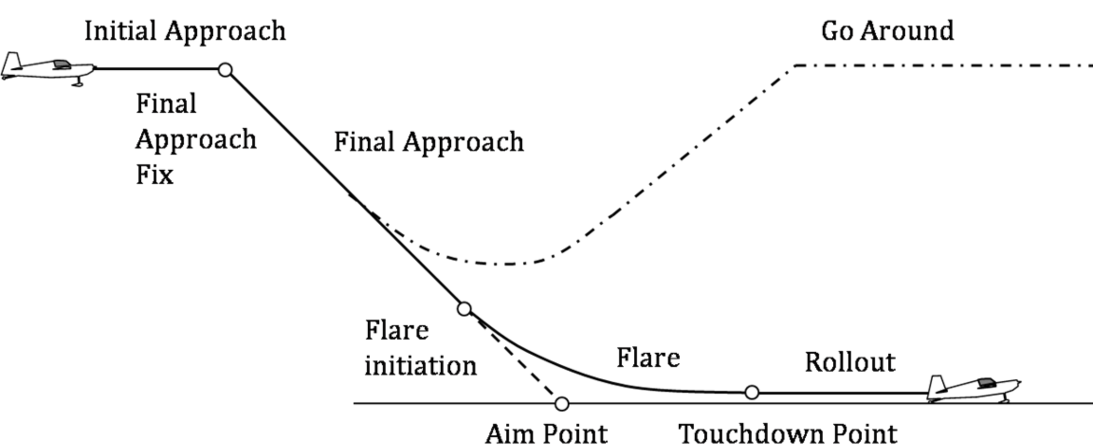
Mentors:

Patrick Quach

Dr. Elizabeth Ward

Auto landing: Overview

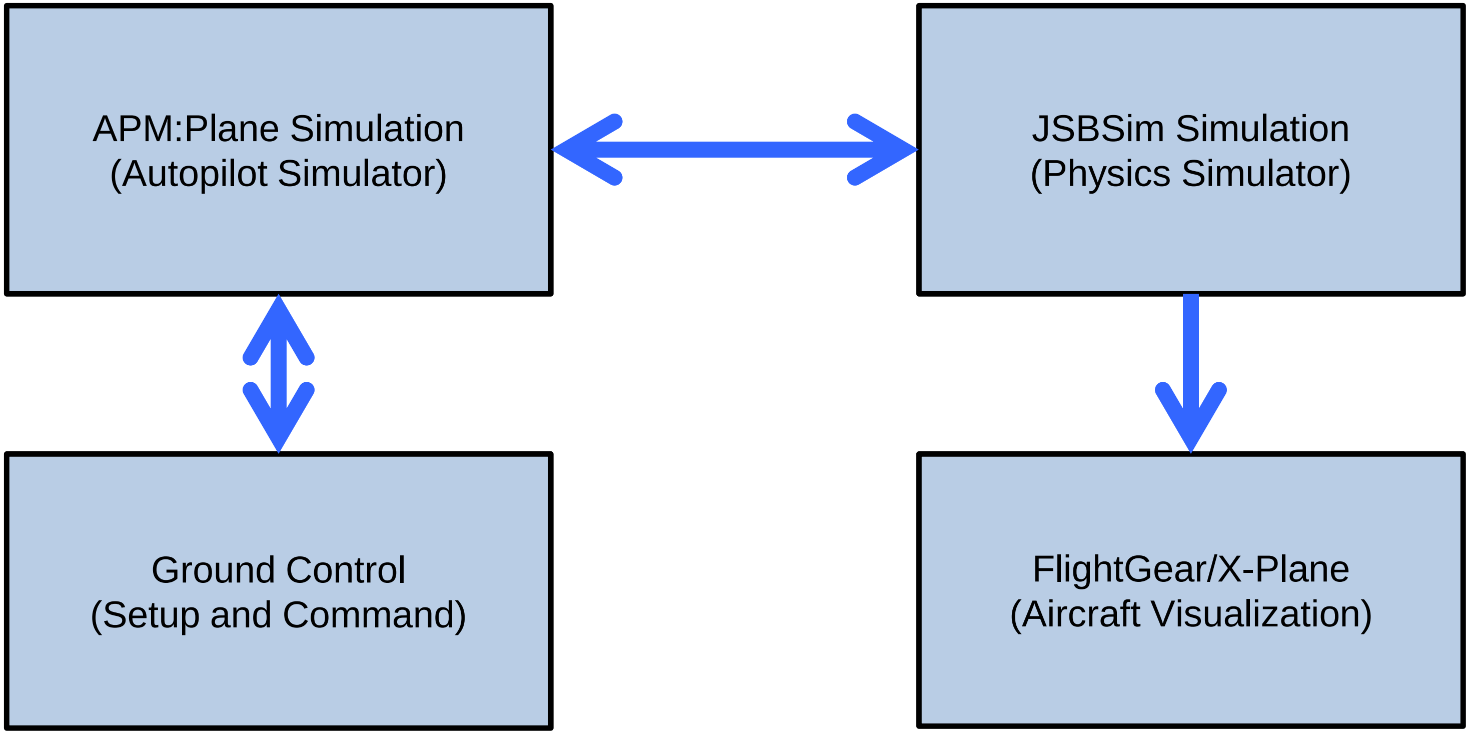
- Objective
  - Develop and integrate an automated landing system for the Edge 540 aircraft from APM software and hardware
- Challenges to overcome
  - Edge 540 aircraft in a “stand down” state
  - Testing the system without an airframe



Credit: NASA Langley SCASB

Auto landing: Software in the Loop (SITL)

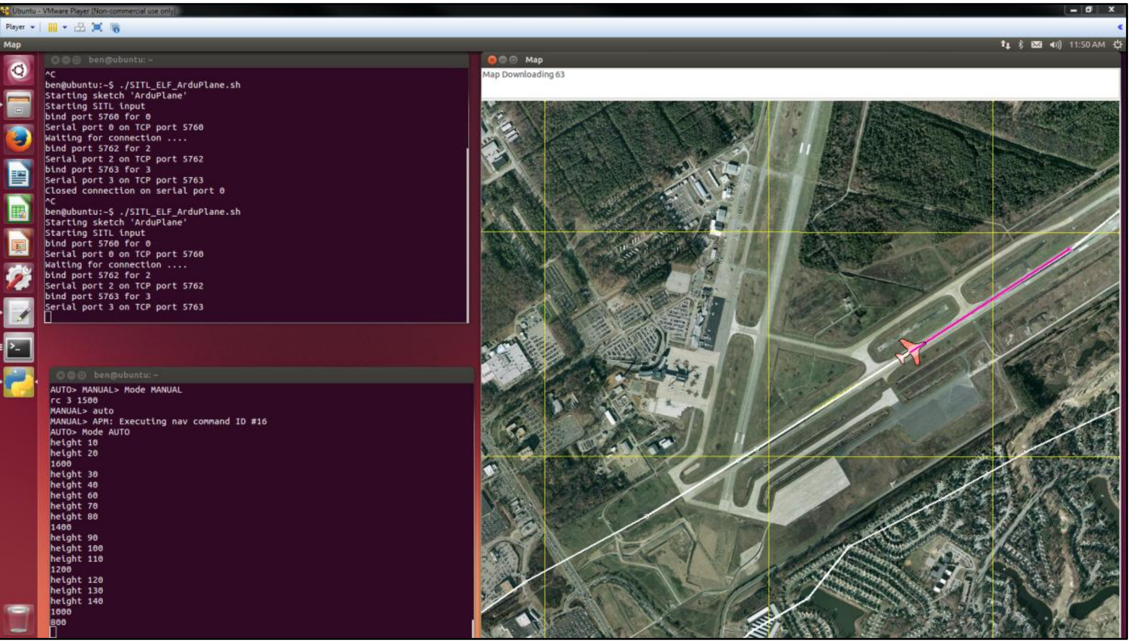
- What is it?
  - A standalone software based testing method
- How does it work?



Auto landing: SITL

- Independent of hardware used
- Dozens of simulations can be run at once
- Safe and reliable

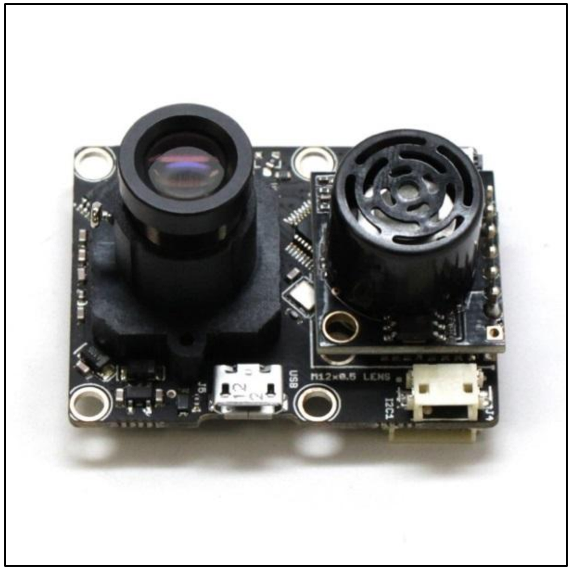
- Solid understanding of hardware abstraction
- Difficult to alter or add sensor emulation

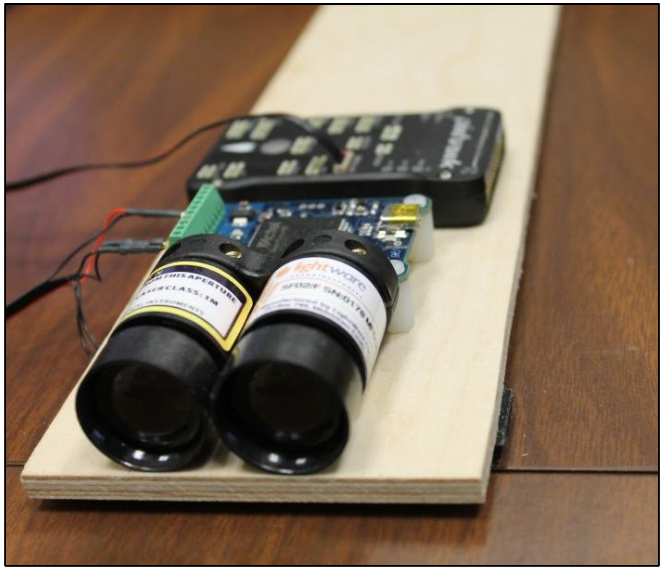


```
/* report SITL state via MAVLink */
void SITL::simstate_send(mavlink_channel_t chan)
{
    double p, q, r;
    float yaw;

    // we want the gyro values to be directly comparable to the
    // raw_imu message, which is in body frame
    convert_body_frame(state.rollDeg, state.pitchDeg,
                       state.rollRate, state.pitchRate, state.yawRate,
                       &p, &q, &r);

    // convert to same conventions as DCM
    yaw = state.yawDeg;
    if (yaw > 180) {
        yaw -= 360;
    }

    mavlink_msg_simstate_send(chan,
                              ToRad(state.rollDeg),
                              ToRad(state.pitchDeg),
                              ToRad(yaw),
                              state.xAccel,
                              state.yAccel,
                              state.zAccel,
                              p, q, r,
                              state.latitude*1.0e7,
                              state.longitude*1.0e7);
```

Auto landing: Hardware Interface

- **Software baseline:** APM:Plane 3.0.1
- **Hardware used:**
  - 3DR: Pixhawk, GPS, Telemetry radio, and Optical Flow Sensor
  - LightWare SF02/F Laser Rangefinder

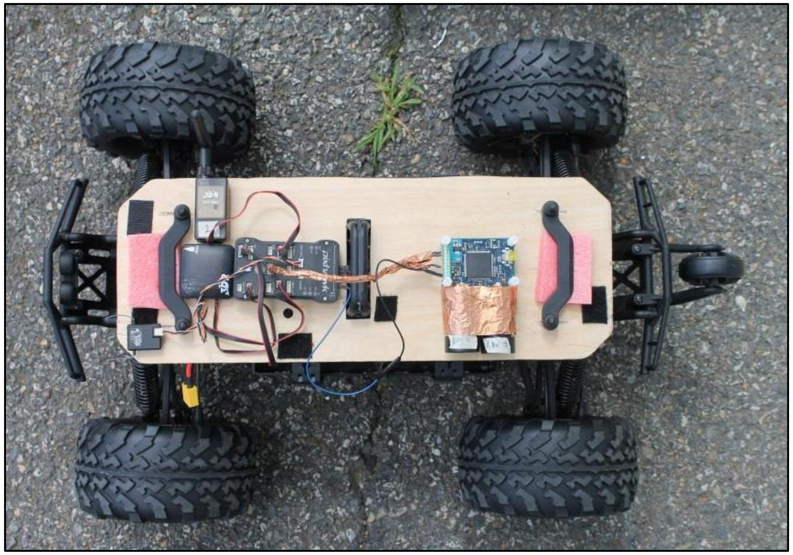




Credit: 3D Robotics

Auto landing: Ground Test

- All terrain RC cars used
  - No airframe available at the time
- A Hangar door was used as the "ground"



- Research Outcomes:
  - Software in the Loop success
  - Laser interference characterized
  - Ground testing method developed

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Questions

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