Model Aircraft Angle of Attack Sensor

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Abstract *— This project focuses on designing a compact, lightweight, and affordable angle of attack sensor for model aircraft, thus providing real-time data to users. This sensor will be placed on the aircraft's leading edge, with easy installation and compatibility with standard controllers. The research explores various methods for determining the angle of attack and selecting the best system for integration into a small, cost-effective device. The sensor is not yet available in the market and is expected to appeal to aero-modelists, due to it enhancing flight dynamics in their models. Additionally, the project could have military applications as the demand for drones and small aircraft grows. By achieving a simple design with accurate data collection, the prototype is expected to significantly improve flight control without affecting aircraft performance. The sensor's marketability stems from its practicality, affordability, and potential use in both hobbyist and defense sectors.*

Key Terms *— Aero-modelists, Angle of Attack, Sensor, Real-time Data.*

PROBLEM STATEMENT

Design a relatively compact, light & inexpensive angle of attack sensor that the typical controller can read. This sensor will be placed on the leading edge of the model aircraft. It will be quick and simple to install. This new and unique system will provide the user with real-time data of the angle of attack on the airplane.

Research Description

This research will focus on studying various methods and systems of determining the angle of attack of an airplane and selecting the best one to employ in a compact invention. This sensor is something that is not available on the current market and could be something that many aero-modelists would want to purchase to include on their airplane.

Research Objective

This project expects to design a prototype of an angle of attack sensor with accurate reading precision which will be very simple to install on an airplane and will not affect the aircraft's performance.

Research Contributions

The successful completion of this project will allow many avid aero-modelists to include a critical component of flight dynamics in their hobby. Since this system will be compact and inexpensive it will be very marketable and will want to be purchased by many people. This system could also have a military application since the military’s use of drones and small aircraft is becoming more common.

LITERATURE REVIEW

This aerospace engineering project is aimed to design a prototype of a sensor that can measure the angle of attack (AOA) of model aircraft. First, a comprehensive explanation of what exactly the angle of attack of an airplane is and its applications will be discussed. Followed by an explanation of the three main technologies used by aircraft today to measure the angle of attack. Other methods for determining the angle of attack that are not practical will be studied but not included in this literature review. Of all these methods, the most practical, compact, and light will be selected to develop.

The angle of attack (AOA) is the angle formed by the relative wind direction and the aircraft's wing chord line and/or the longitudinal axis of the airplane [1]. Stated differently, the aircraft angle of attack is the angle formed by the incoming air with the fuselage center or a designated average point on the wing. The pitching angle of the aircraft, which is related to its angle with the horizon, should not be confused with the angle of attack. Similarly, the angle of the flight path vector with respect to the horizon is known as the flight path angle, and it can also occasionally be confused with the aircraft AOA. See figure 1 below.

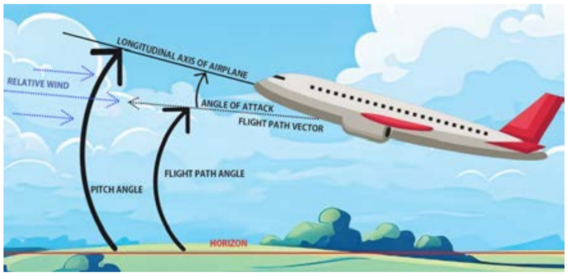


Figure 1
Angle Differences

The angle of attack is a crucial element influencing aerodynamic forces. Additionally, it is employed to assess aircraft stability and performance, which aids in identifying the aircraft's limits. Currently, conventional aircraft often use angle of attack instrumentation to assess flying safety. In big, heavy aircraft that often travel at a high speed, these devices aid in preventing stalling. Stalling occurs when the angle of attack of an airfoil exceeds the value which creates maximum lift. There is a greater lift force when the AOA increases because of the increased coefficient of lift. See figure 2.

At the critical angle of attack (stall point), the lift coefficient reaches its maximum and then starts to fall. Above the critical AOA, the approaching flow totally separates from the wing's surface which in turn causes a dramatic drop in lift, also known as the stall AOA.

Even though aircraft have a stall speed, which is the minimum speed the airplane has to be moving for the plane to produce lift, the best way to prevent a stall is not through speed. A much more useful metric to employ is tracking the angle of attack. Even though the speed of the aircraft affects its stall point, a plane can stall at any speed. For a set configuration, an aircraft will always stall at the same critical angle of attack. Neither the center of gravity, density altitude, air temperature, nor weight change the value of the critical angle of attack [2].

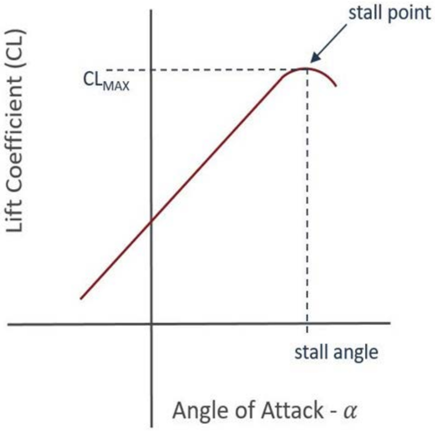


Figure 2
Lift Coefficient vs. Angle of Attack

Angle of attack indicators will specifically work to reduce loss of control accidents. In both general aviation and commercial aviation, loss of control is the leading cause of fatalities. Over 25% of fatal accidents in general aviation happen while the aircraft is performing a maneuver. Of those incidents, stall and spin situations account for 50%. These indicators can give a visual depiction of the energy management state of the airplane in real-time. The energy state of an aircraft is the balance between airspeed, altitude, drag, and thrust and represents how efficiently the airfoil is working. With this increased situational awareness, the pilots will have the information they need to prevent a loss of control situation resulting from a stall/spin. Furthermore, a plane that requires less energy to maintain flight has a higher overall efficiency, which is usually translated into fuel and cost savings.

The aerodynamic drag an airplane produces while in flight is greatly influenced by its angle of attack (AOA). A rise in the leading edge of the wing causes the airflow on its upper surface to accelerate and change from laminar to turbulent flow. Consequently, an aircraft's overall drag rises. Total drag is a combination of parasite drag (form, skin friction, and interference) and lift-induced drag.

As wind wraps around the tips of the wings, spirals of air pockets known as wingtip vortices are formed. Downwash from wingtip vortices causes lift-induced drag as a byproduct. The strength of the wingtip vortices rises with increasing AOA, increasing lift-induced drag. During an ascent, drag due to lift can account for up to 70% of the overall drag and less than 5% during high-altitude level flight.

Types of AOA Indicators and How They Work

We will study each of the three primary categories of angle of attack indicators below. These are: transducers (alpha vane and stagnation point), differential pressure sensors, and inertial reference indicators. Every type has specific factors to take into account and determine the angle of attack in different ways [3] [4].

Transducer AOA Indicators

Transducer types are the most widely utilized AOA indicators in aviation today. These indicators are made to be able to measure the angle of attack directly and to move in response to the relative wind hitting the plane and/or airfoil. The alpha vane and stagnation point transducers are the two types of transducer AOA indicators that are most frequently employed:

- **Alpha Vane Transducer:** Alpha vane transducer AOA indicators are the ones that are used by most commercial airplanes. These vanes are fixed to the aircraft and are free to move and rotate in response to the direction in which the wind strikes the aircraft (and therefore, the vane). Based on how the wind is pushing it, the vane measures the angle of attack precisely and in real time. See figure 3.
- **Stagnation Point Transducer:** Stagnation point transducer AOA indicators are mounted on the airfoil's leading edge and are free to move up and down in response to changes in the direction of the wind [5]. The transducer is able to measure the angle of attack of the plane immediately at any given time based on the angle at which it is pushed upward or downward. The air mass is divided by the airplane wing as it passes through it. The stagnation point (red line) is a small area in the middle of this split airflow, refers to figure 4.

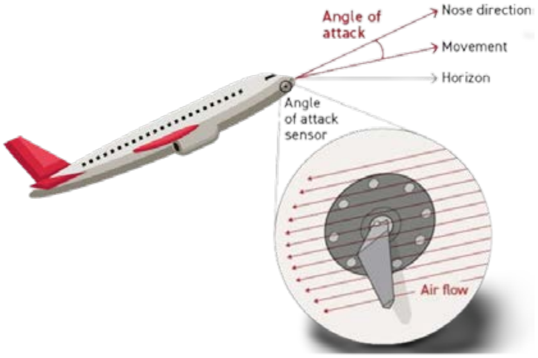
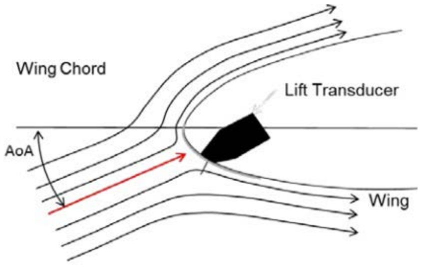
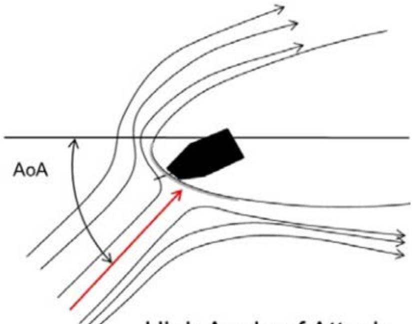


Figure 3
Vane Transducer Principles



Low Angle of Attack



High Angle of Attack

Figure 4
Stagnation Point Transducer Principles

The wing's angle of attack is uniquely represented by the stagnation point's location. The leading-edge stagnation point on the lower surface of the wing shifts aft chordwise as the angle of attack grows. Through the use of a spring-loaded vane, the lift transducer senses where the stagnation point is. The lift transducer is engineered to identify the stagnation point's location and transmit this information to the airplane's computer. The transducer's placement on the wing has to be carefully considered in order to maximize the sensed airflow throughout the aircraft's high-lift performance regimes. These comprise the angles of attack that give the optimal long-range cruise and maximum endurance, as well as maximum wing lift during short-field takeoff and landing operations. As may be seen in the diagram above, decreasing the angle of attack of the wing moves the stagnation point forward (up); increasing the angle of attack moves it aft (down). At a maximum aft (rear) position, wing lift rapidly decreases, which is the angle of attack at which the stall occurs.

- **Differential Pressure Indicator:** Differential pressure angle of attack indicators, as the name implies, use the pressure difference between two ports to determine the angle of attack. Usually, these indicators are probes with two holes drilled at different angles that are fastened to the wing. The holes receive varying pressure in relation to one another when the plane's AOA varies, allowing for the calculation of the angle. See figure 5.

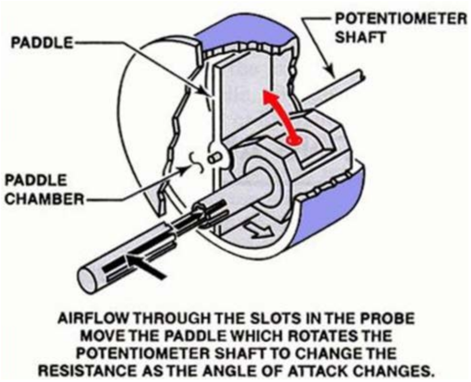


Figure 5
Principles of Differential Pressure Indicator

- **Inertial Reference Indicator:** The only one of the three that measures the angle of attack indirectly rather than directly is the inertial reference angle of attack indicator [6]. These operate by measuring the aircraft's pitch angle and flight path angle. The angle of attack is, by definition, the difference between these two angles. However, because the angle is not measured directly, errors in accuracy are produced in some situations. Figure 6 explains:

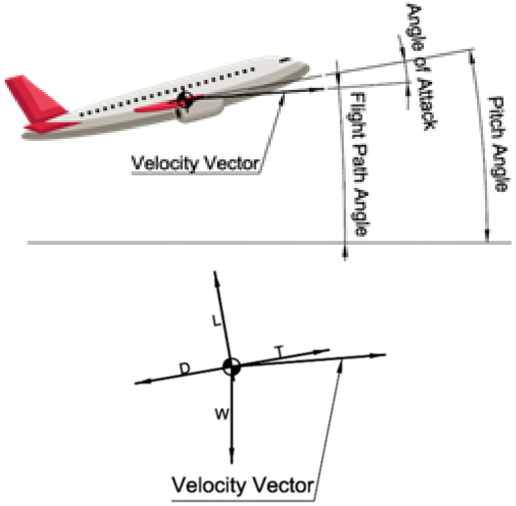


Figure 6
Principles of Inertial Reference Indicator

In short, after evaluating these different methods of determining the angle of attack, the most evidently practical for the project is the alpha vane transducer. This sensor will measure the angle of the vane in relation to the chord-line of the airfoil. The vane will always want to be aligned with the free stream. Therefore, as the airplane pitches the nose up (or down) the chord-line will change angle while the vane stays aligned with the free-stream. Through calibration, we will be able to calculate the angle of attack. This type of sensor is the least invasive on the structure of the airplane and can be something simple to install directly on an already built airplane. A simple design would have to be developed that could be attached to the leading edge of a flying model either by screws or double-sided tape. After the prototype is developed, wind tunnel calibration and testing can confirm that the sensor is actually reading the correct angle of attack. With this additional data, the pilots will have the information they need to prevent a loss of control situation and, therefore a crash. Another advantage this could offer is that it would make formation flying much easier since all the pilots would fly at the same angle of attack instead of relying solely on visual adjustments.

METHODOLOGY

In this section, a general outline of the development of the project will be provided.

Phase 1 – Optimization & Placement

Sensor Exact Placement - For this sensor to work correctly it must meet certain conditions:

- Firstly, it must not be in the slip stream of the propeller; this means that it should not be close to the fuselage but further out on the wing. As a rule of thumb, it will have to be at least a spanwise distance of 1.5 the radius of the propeller.
- Secondly, it must be placed sufficiently forward into the free stream to avoid being influenced by the air that's being separated by the airfoil. This Distance "A" will be given by CFD program validation. Figure 7 shows:

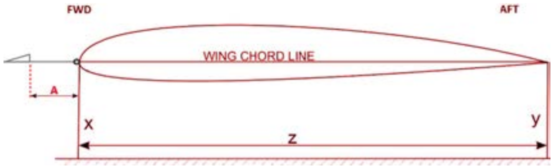


Figure 7
Vane Location Diagram

If the distance "A" becomes too cumbersome or too far forward for a practical design, then a correction for disturbed flow will have to be made. The free stream is considered undisturbed a significant distance away from the airfoil, this is where the influence of the airfoil on the flow field is negligible. There isn't a fixed distance for this, but it's generally considered that 5 – 10 chord lengths ahead of the airfoil the flow is undisturbed. This, however, is a rule of thumb, and it will vary depending on specific conditions such as Reynolds number or Mach number. It's obvious that even the minimal requirement of 5 chord lengths is too bulky or inconvenient so a correction will probably have to be made. The local angle of attack, α_{Local}, at the vane may be influenced by the flow disturbance from the airfoil. To correct for this, we will estimate the induced velocity (and corresponding angle) that the airfoil generates in the flow field. A simple approach is to estimate the induced angle of attack $\alpha_{Induced}$ based on the circulation or lift coefficient of the wing. The total angle of attack can be corrected, refer to (1):

$$\alpha_{Corrected} = \alpha_{Local} - \alpha_{Induced} \qquad (1)$$

Where:

- $\alpha_{Corrected}$ = true free-stream AoA.
- α_{Local} = vane measured AoA.
- $\alpha_{Induced}$ = disturbance induced angle, approximated from the wing's circulation or lift coefficient.

To calculate the estimated induced angle ($\alpha_{Induced}$). For a 2D wing, you can estimate the induced angle of attack based on the lift coefficient C_L and the downwash caused by the airfoil. The induced angle can be approximated as (2):

$$\alpha_{Induced} = \frac{c_L}{2\pi} \qquad (2)$$

C_L is the lift coefficient of the airfoil at that angle of attack (which depends on the shape of the airfoil and its operating conditions) and 2π is from thin airfoil theory for 2D flows. Once the induced angle is estimated, you subtract it from the vane-measured angle of attack α_{Local} to obtain the corrected free-stream angle of attack.

Some considerations:

- Location of the vane: half chord length ahead or/and below of the airfoil is quite close to the disturbance region, so this correction is approximate.
- Wing geometry: The actual induced angle depends on the airfoil geometry, camber, thickness, and flow speed.

- Empirical or CFD data: In practice, accurate corrections might need computational fluid dynamics (CFD) simulations or wind tunnel testing to more precisely estimate disturbances at 1 chord length.

  In summary, it's possible to estimate and correct the angle of attack by placing a vane in front or below the wing and using a formula, but the result will be approximate, especially when the vane is close to the wing.
- The third condition is balancing. Making sure the placement of the sensor does not significantly affect the weight balance or aerodynamics of the aircraft. This means that the materials used will have to be the lightest possible and possibly a counterweight will have to be placed on the opposite wing.

Sensor mounting - The vane will need to be attached to a support extending from the leading edge of the wing of the aircraft. This support should be thin and aerodynamically shaped to minimize interference with the airflow. Materials like lightweight aluminum or carbon fiber can be used for rigidity and minimal mass.

Vane Size - The vane itself should be small and sensitive enough to respond to changes in flow angle but not so large that it creates significant drag. The size could be scaled proportionally to the model aircraft, typically a few centimeters in length.

Phase 2 – Sensor Components and Design

Selecting the type of sensor - As mentioned previously the most practical and convenient indicator, at first glance, is the alpha vane transducer. Since this sensor is the most compact and easiest to install on an already built plane. In second place should this sensor fail to meet the requirements, we would try the stagnation point transducer. The downside to the stagnation point sensor would be the flexibility of using it in different aircraft, since it would require very precise calibration for each individual aircraft.

- Angular Position Sensor: To measure the angle of attack at the vane, a rotational position sensor (like a potentiometer, Hall effect sensor, or digital encoder) can be attached to the vane's pivot point. This will allow for accurate real-time measurement of the vane's deflection due to the local flow angle.
- Precision: The sensor should provide a high resolution to capture small angular changes, ideally measuring angles with a resolution of ± 0.1° or better.
- The vane may experience disturbances due to the presence of the wing, so a correction may need to be applied to the measured angle of attack to better estimate the free-stream AoA.
- If needed, this correction can be calculated in real-time using an embedded microcontroller or a small onboard computer, such as an Arduino or Raspberry Pi, depending on the complexity and required computational power.
- The microcontroller will use the pre-programmed correction formula (3):

$$\alpha_{\text{Corrected}} = \alpha_{\text{Measured}} - \alpha_{\text{Induced}} \qquad (3)$$

Where α_{Induced} is estimated from the lift coefficient, which could be programmed based on wind tunnel testing or aerodynamic data for the airfoil and Reynolds number.

- The system will need to process the measured angle (α_{Measured}) from the sensor and apply the correction factor in real-time to estimate the true free-stream angle of attack. For real-time processing the onboard microcontroller must be fast enough to process the measured data and apply corrections during flight.
- The sensor system should log data to an onboard storage device (e.g., an SD card) for post-flight analysis.
- Without adding weight, a link cable could be connected to the inside the fuselage in order to be able to transmit wirelessly to a ground station using a simple radio transmitter for real-time monitoring. Bluetooth connectivity could also be explored.

- The sensor system will require a small onboard power supply, such as a lightweight lithium polymer (LiPo) battery. Power requirements will depend on the chosen microcontroller and sensors, but typically a small battery (e.g., 3.7V or 7.4V LiPo) would suffice. The better option being to connect to the same battery used to control the airplane’s servos.
- The vane sensor should be encased in a lightweight, weatherproof housing to protect it from moisture and debris during flight. The housing should be designed to be as lightweight and aerodynamically neutral as possible to avoid interfering with airflow and affecting the performance of the model aircraft.

Phase 3 – Calibration

(Beyond the scope of this project)

Wind tunnel test - One the sensor is installed into the wing it will be taken to a wind tunnel to test at different angles of attack. A fixed reference inside the tunnel will help position the wing at a predetermined angle of attack. A wind speed of 20 - 30 miles per hour will be used since this is the speed at which RC model airplanes normally fly at. First, the wing is to be put a 0° AOA, to verify what the sensor reads. Subsequently, different angles will be tested until the critical angle of attack is reached and calibration is finalized.

Phase 4 – Field Tests

(Beyond the scope of this project)

Flying the model - Once calibration has been achieved the wing will be reinstalled on the airplane and taken to perform test flights. The data from this flight testing is to be analyzed to perform optimizations on the design or placement of the sensor.

Phase 5 – Optimization & Cost Analysis

(Beyond the scope of this project)

Selling the product - Once the system is fully calibrated and tested to work, a further implementation onto already existing models can be made. This system should be affordable and easy to install, so to make it commercially viable a simple package with everything integrated into one sensor connected via one small cable to just one board would be ideal. The system would have to be modified to use power from the batteries the model airplane already uses to power the servos and receiver. The price range of all this equipment is estimated to be around $100.

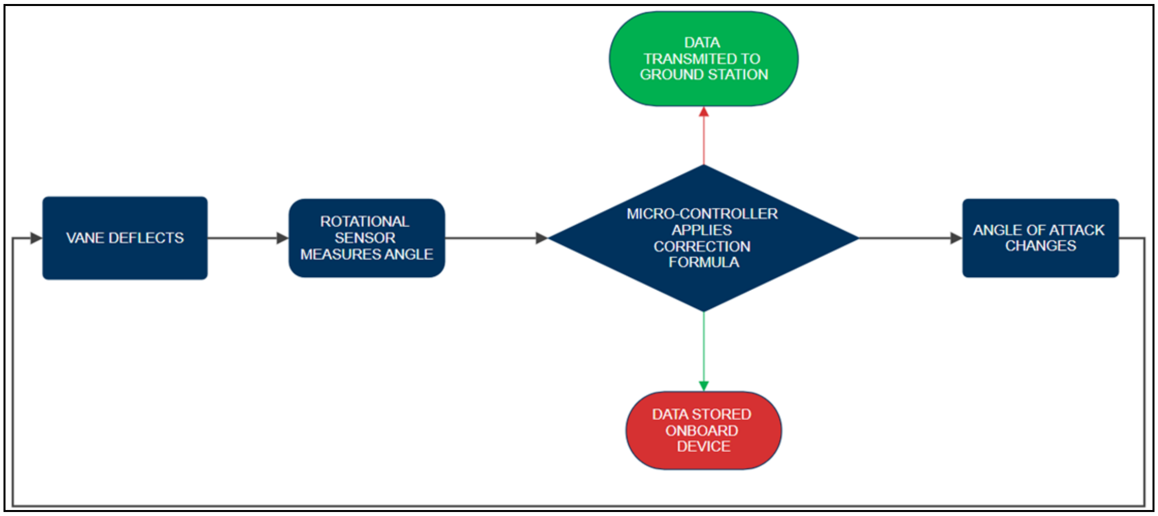


Figure 8
Design Workflow

RESULTS AND DISCUSSION

On this section the results and CFD images of the project will be detailed. The aircraft for this project is the Polytechnic University of Puerto Rico SAE Aero Design model aircraft. This airplane has won several championships including, First Place Overall SAE West 2022 - Regular Class, First Place Performance SAE West 2022 - Regular Class. The airfoil this aircraft uses is S-1223.

Phase 1 – Optimization & Placement

Sensor Exact Placement - After several tests in CFD it is determined that for this airplane the vane's optimum location will be at the mean aerodynamic chord 44.875 inches spanwise. The mean aerodynamic chord (MAC) is the average chord length of a wing. Since most wings are tapered or have varying shapes and chord lengths along their span, the MAC provides a single value that represents the aerodynamic center of the wing as if the entire lift was generated by a constant-chord wing. This places the sensor just outside the interference with the propeller's slip stream and minimizes how far outward the sensor is placed since the sensor's weight will cause a lever effect in terms of longitudinal balance. In the images below (Figure 10, 11 & 12) we can see the ANSYS rendering image, using the Aero Design's wing with the S-1223 airfoil. The complete wing was rendered and evaluated placing the sensor at different locations. We can clearly see that the free stream is not disturbed in all three positions. Therefore, the mathematical correction (αCorrected = αMeasured - αInduced) will not be needed to provide the correct angle of attack since the vane can provide it directly. The vane position was determined to be optimal coming out of the leading edge and normal to the wing chord in the downward direction half a chord's distance. Consequently, the distance "A" will be equal to half the chord's length, the chord length used will be that of the mean aerodynamic center (figure 9).

$$A = \frac{chord}{2} \tag{4}$$

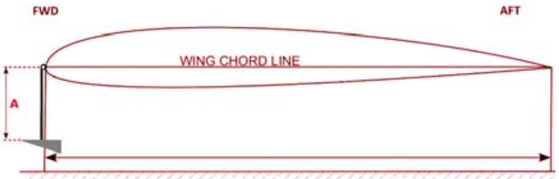


Figure 9
Correct Vane Location

Sensor mounting - The vane and sensor will be attached to a carbon fiber rod extending (90° from chord line) downwards from the leading edge of the wing. This support rod should be less than ¼ inch in diameter to avoid excessive turbulence but maintaining rigidity. The rod should not bend as this will distort the measured angle.

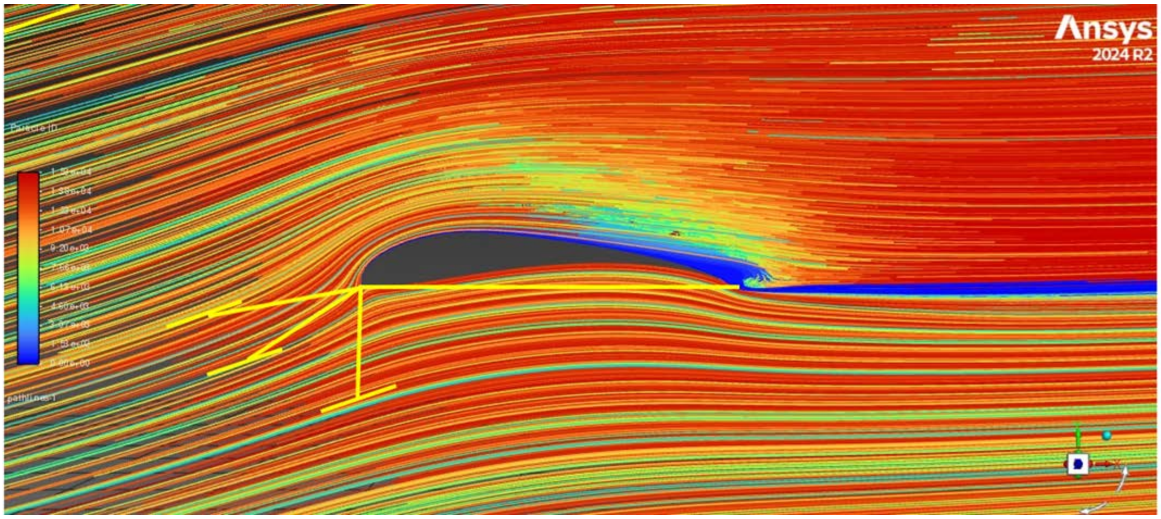


Figure 10
Ansys Rendering of S-1223 Airfoil

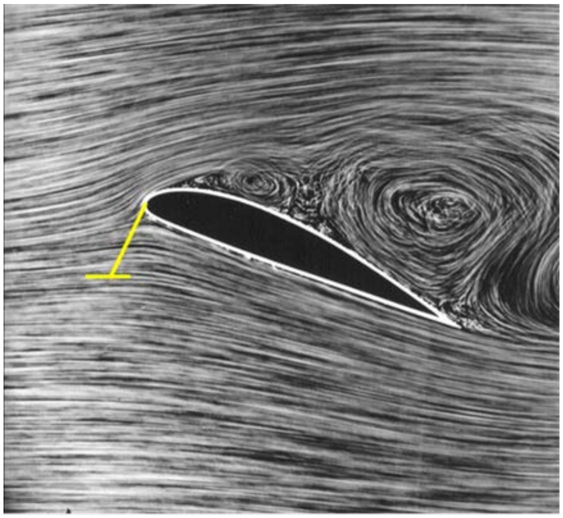


Figure 11
Vane at High Angle of Attack

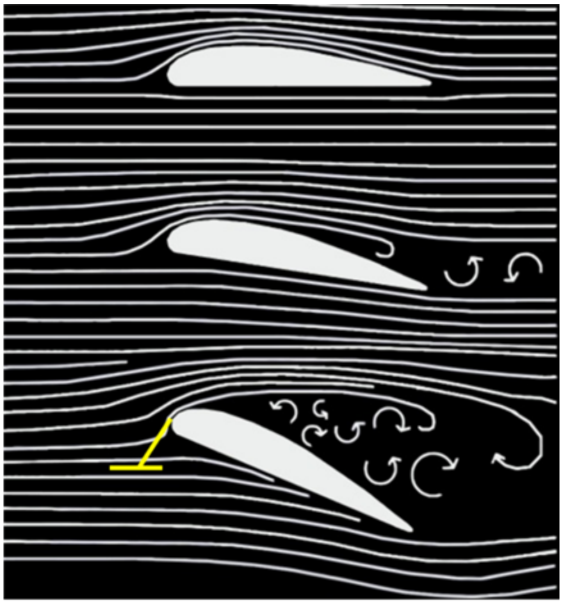


Figure 12
Drawing of Vane at High Angle of Attack

Vane - The vane should be made of a lightweight material such as carbon fiber, thin aluminum, or lightweight plastic (in case of 3D printing). These materials ensure that the vane has a low mass and won't cause inertia that would delay its movement or affect its sensitivity.

The size of the vane should be 5% to 10% of the MAC chord length. The size needs to be large enough to respond to airflow changes but small enough to avoid causing unnecessary drag or turbulence that affects the flight performance. A thin, elongated, flat plate design with balanced areas in front and behind the pivot. The vane will have a symmetric shape to avoid bias and should be strong enough to withstand dynamic loads during flight.

The vane will have a symmetric design around its rotational axis to ensure that it responds equally to airflow from both sides. This will also help the vane align with the airflow accurately without bias. The center of mass of the vane should also be positioned along the rotational axis to avoid introducing rotational inertia that would cause inaccurate readings and slow response times. A slightly elongated aspect ratio (length greater than width) will improve the sensitivity to small changes in flow direction while avoiding excessive fluttering. The area in front and behind the pivot point (the rotational axis) should be balanced to ensure quick and smooth responses to the airflow. The are of the vane behind the pivot is larger than the area in front to ensure that the vane is pushed into alignment with the airflow. The axis of rotation should be near the center of the vane but slightly biased toward the front to make the rear surface larger, so it remains balanced in the airflow and sensitive to direction changes.

Phase 2 – Sensor Components and Design

Angle Measurement System - The optimum angular position sensor for this application will be a magnetic rotary encoder, the AMS AS5600 (Figure 13). This encoder is compact, highly durable and provides 12-bit resolution, in addition to being compatible with multiple microcontrollers, making it ideal for precise angle measurement in outdoor conditions.

Figure 13
AMS AS5600

Induced Angle of Attack Correction

Reynolds Number Ranges for Model Aircraft:

- Slow-flying indoor model aircraft: Reynolds numbers typically range from 10,000 to 50,000 (small aircraft, low airspeed).
- Standard RC aircraft: Reynolds numbers are often in the range of 50,000 to 200,000 depending on the size of the model and the flight speed.
- Fast RC jets or large UAVs: Reynolds numbers can go into the range of 200,000 to 500,000 especially if the model is larger or the airspeed is higher.
- For our project we are using a typical RC aircraft so we will assume a Reynolds number of 100,000.
- Reynolds calculation (5):

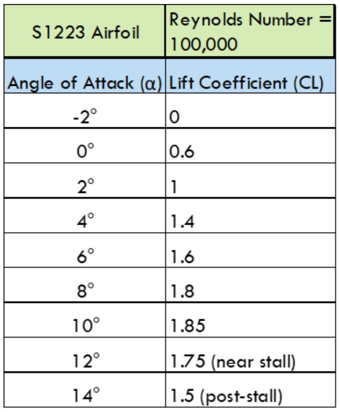
$$Re = \frac{\rho \cdot V \cdot L}{\mu} \tag{5}$$

- Airspeed (V): 10 m/s (22.4 mph a typical speed)
- Chord Length (L): 0.15 m
- Air Density (ρ): 1.225 kg/m3 (standard sea level)
- Dynamic Viscosity of air (μ): 1.81 x 10-5

$$Re = \frac{1.225 \cdot 10 \cdot 0.15}{1.81 \times 10^{-5}}$$

$$Re \approx 101{,}400$$

Table 1
Lift Coefficient for the S1223 Airfoil at Various AoA



S1223 Airfoil	Reynolds Number = 100,000
Angle of Attack (α)	Lift Coefficient (CL)
-2°	0
0°	0.6
2°	1
4°	1.4
6°	1.6
8°	1.8
10°	1.85
12°	1.75 (near stall)
14°	1.5 (post-stall)

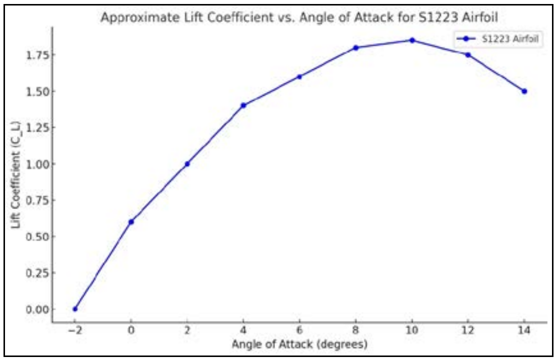


Figure 14
Lift Coefficient vs. Angle of Attack for S1223

The graph (figure 14) above shows the approximate lift coefficient CL versus the angle of attack for the S1223 airfoil. As seen, the peak lift occurs at around 10°, this is typical for this airfoil which is designed for high lift performance at low Reynolds number.

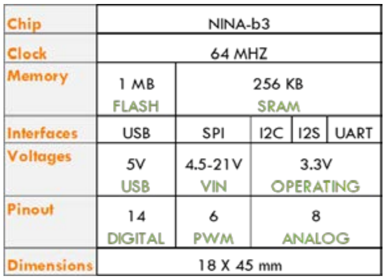
Airfoil Key Observations

- High Lift at Low angles: The S1223 achieves high lift coefficients even at relatively low angles of attack. For example, CL = 1.6 at only 6° of angle of attack.
- Peak Lift Coefficient: The peak lift coefficient is around 1.85, which typically occurs at an angle of attack between 10° and 12° depending on the Reynolds number. This is a high value for a low Reynolds number type of airfoil. This makes the S1223 well-suited for high lift applications.
- Stall Behavior: The airfoil begins to stall around 10° to 12°, where the lift coefficient starts to decrease as the AoA increases.

Data Processing and Output

Given that we require real-time processing of data and correction calculations in a lightweight package, the best option for this microcontroller application is the Arduino Nano 33 BLE – this microcontroller will provide the processing capability needed for our sensor and corrections while keeping the system lightweight and power-efficient. This board also has the possibility for Bluetooth® Low Energy connectivity. This could be useful for transmitting the data wirelessly to a ground station.

Table 2
Arduino Nano 33 BLE Specifications



Chip	NINA-b3				
Clock	64 MHZ				
Memory	1 MB FLASH	256 KB SRAM			
Interfaces	USB	SPI	I2C	I2S	UART
Voltages	5V USB	4.5-21V VIN	3.3V OPERATING		
Pinout	14 DIGITAL	6 PWM	8 ANALOG		
Dimensions	18 X 45 mm				

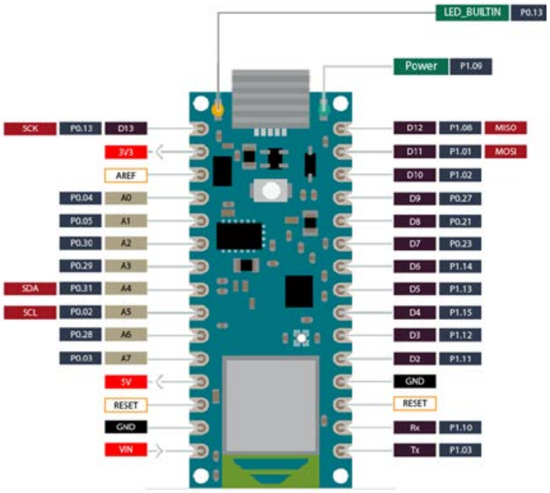


Figure 15
Arduino Nano 33 BLE Pin Out

Power Supply

AMS AS5600 Power Requirements:

- Operating Voltage: 3.3V to 5V
- Power Consumption: Less than 10 mA

Arduino Nano 33 BLE Power Requirements:

- Operating Voltage: 3.3V
- Power Consumption: Typically, 20-50 mA
- Can be powered via USB (micro-USB port)

Power Supply Options:

- Given that both operate at 3.3V, and they both draw minimal current, for simplicity and minimal weight, the single-cell LiPo battery (3.7V) with a 3.3V regulator is the best choice for this application.
- The second option, to avoid additional regulators, is to use a 5V power bank, which powers the system via the Arduino’s onboard voltage regulator.

Housing and Durability:

- The rotary sensor will be encased in a lightweight, weatherproof housing to protect it from moisture and debris during flight.

CONCLUSIONS

The successful completion of the angle of attack (AoA) sensor design marks a significant achievement in accurately measuring and correcting disturbed flow conditions on a model aircraft. By placing a vane at half chords length below the wing and running CFD simulations in Ansys, we were able to accurately estimate the (free stream) real angle of attack, overcoming the disturbances caused by the proximity to the airfoil. The sensor's high-resolution angular measurement, combined with efficient aerodynamic principles, will provide reliable and precise angle of attack data throughout flight tests.

This system demonstrated its effectiveness in real-time applications, with outputs stored on a local SD card and transmitted wirelessly to a ground station. The data logging feature will enable detailed post-flight analysis, validating the system’s performance in various flight conditions. The lightweight and aerodynamically designed housing will minimize interference with the aircraft's performance, proving that the sensor is practical for use on small-scale model aircraft without compromising their flight characteristics.

The project offers a valuable tool for aerodynamic testing and performance optimization, particularly in the realm of model aircraft and other small UAVs. It provides a foundation for further improvements, such as enhanced data processing, integration with other flight systems, or adaptation to larger aircraft. Overall, the successful implementation of the AoA sensor opens new possibilities for flight analysis and real-time feedback, ensuring more accurate control and optimization in future aerospace applications.

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