International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 4, Issue 8, August – 2020, Pages: 316-322

Linear Modeling with the Atmospheric Pressure Altitude and Direct Indicator Altitude through the Altimeter Simulator of the Aircraft

Amupitan Martins A[1*], Olabimtan Olabode.H[2] & Ashraf Mahmud.R[3]

[1]Nigeria College of Aviation Technology, Aircraft Maintenance Engineering School Zaria Kaduna State, Nigeria.
[2]National Research Institute for Chemical Technology, Department of Industrial and Environmental Pollution, Zaria Kaduna State, Nigeria.
[3]Chittagong University of Engineering and Technology, Mechanical Engineering Department Chittagong, Bangladesh.
Corresponding author email*:Delemart74@gmail.com

Abstract: *Aviation is rapidly growing, particularly in developing countries, and there is a great need for understanding the mathematical modeling required in the training with more sophisticated aircraft in increasingly crowded and complex airspace. This paper modeled ($y = 0.010x – 0.04$ at $R^2= 0.9920$) the aircraft pressure altimeters as a singular parameter with the elevation of the aircraft above a defined datum of 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 feet at a constant and standard QNH of 1,013.3 hectopascal which is practically the pressure on the altimeter's subscale above the sea level to establish a linear relationship with the indicated altitudes at the same unit status.*

Keywords: Aviation, mathematical modeling, aircraft pressure altimeter and indicated altitude.

1.0 INTRODUCTION

In aerospace engineering, the pressure point indicates the altitude beyond a standardized datum plane (SDP) that is a theoretical value where the ambient weight is 29,921 inches of mercury with the equivalent of 1,013.2 mbar and 14,696 psi as recorded [1]. This means the elevation achieved by fixing the altimeter at the accepted minimum altitude in such conditions where the altimeter of the aircraft will not be able to provide a useful altitude measurement. Typical of Examples will be landings at high altitudes or close to atmospheric pressure under exceptionally high air pressure levels. Commonly, traditional altimeters were confined to projecting the altitude between 950 and 1030mb [1]. The commonly used reference in pressure is hectopascals (hPa) equals to 1013.25 Mb or 29.92 inches of mercury [2]. This atmosphere is similar to the International Standard of Atmosphere (ISA) at the average sea level pressure [2]. Stress altitude is used mainly in the measurement of aircraft efficiency and in high altitude flight above the altitude of transition. Stress is a contrast between two opposing effects as there is absolute pressure when a force is compared with a complete pressure in a vacuum. Absolute pressure must be established since ambient air is always putting pressure on every matter. Also when there appears to be no pressure being exerted, as to how a bubble is deflated, the pressure of air within and outside the bubble is still there. To evaluate the air pressure, there must be a comparison to an absolute absence of air. Several aviation sensors feature gauge pressure values, including the altimeter, the level-of-climb detector, and the pressure gauge for the manifold [3]. Typically this is accomplished using an aneroid, as specified. Gauge pressure tends to be the most common form of pressure measurement. This would be the variance between the actual pressure and the ambient pressure as gauge pressure is easily determined and attained by hiding the fact that the air generates its energy on anything at all times. Besides for instance, at a location at sea level, a tire is filled with air to 32 psi and tested with a scale to read 32 psi, which is the pressure gauge. This lacks the approximately 14.7 psi of air pushing on the tire's outside. The total tire pressure is 32 psi with an additional 14.7 psi required to stabilize the 14.7 psi outside of the tire pressure [3]. The total pressure of the rubber is around 46.7 psi as the same tire is pressurized to 32 psi at a position of 10,000 feet above sea level, where the atmospheric pressure outside of the tire will be 10 psi [3]. The pressure within the tire necessary to handle this would be 32 psi plus 10 psi, rendering the tire 42 psi of absolute pressure [3]. Therefore the same tire has different total pressure values with the same sum of inflation and performance characteristics. However, the gauge pressure remains unchanged, suggesting the tires are identically inflated. For this scenario, gauge pressure seems to be very useful as an Indicator of the tire’s condition. Observations with the pressure gauge are fast and extremely useful as they prevent the need to calculate varying atmospheric pressure. For certain situations in aviation, a comparison of the stresses of two different elements is necessary to conclude a piece of valuable information for operating the airplane. As measured with two pressures around a particular gauge with the calculation as differential pressure. To calculate how quickly the aircraft is going through the air, it matches the ambient air pressure with the ram air pressure which is the air that is enforced through an opening. The differential pressure gage is the pressure ratio of the engine (EPR) indicator of a turbine. This relates the stress at the engine's inlet to that of the outlet to reflect the engine's thrust [3]. A widely used pressure in aeronautics is referred to as standard pressure which applies to a fixed or uniform value produced from the ambient pressure. At the point of 1,013.2 hPa, or 14.7 psi, the normal pressure density is 29.92 inches of mercury [4]. It is an existing standard that includes a standard temperature at sea level of 15 ° C. Particular standard day values for air volume, density, and viscosity were also established. The values however are statistics developed as the atmospheric conditions fluctuate constantly. These are applied by engineers, pilots, and technicians in developing instrumental systems. The use of a standard value for the environmental pressure is often more acceptable than the actual value. At 18,000 feet or above, most aircraft need 29.92 Hg as a reference pressure to represent altitude for their measurements as it results in equal altitude signs in the entire cockpits. Consequently, an effective method of keeping aircraft flying vertically at such high altitudes is developed. The pilot's main significant instrument for interpreting the engine's safety is the pressure gauge of the engine oil in psi with the standard operating range that is defined on the circular gauge by a green arc [5]. To precise suitable operation range, check the manufacturing and maintenance information of the maker. Oil is often used in the propeller and spinning engines that grease and cool the bearing surroundings as the parts spin at high revolution against one another [3]. The depletion of compresses oil under pressure to these regions will immediately lead to extreme resistance with over-temperature situations, leading to devastating engine defects [3]. Noticeably, aircraft with analog devices also use the Bourdon tube oil pressure gages for direct reading (Figures 1 and 2). An aneroid attached with an evacuated enclosed section (Figure 3), A bellows device in a differential pressure gauge comparing two differential pressure levels with the configured indicator (Figure 4) and Figure 5 revealing the face of the instrument of a standard oil pressure gauge. The digital systems with a controlled digital or analog oil pressure sensor module which transfers output to the computer, controlling the projection of oil pressure measurements on the cockpit display screens of the aircraft. Oil pressure can be seen in a linear or circular gauge format and may even generate a screen number value. Usually, the pressure induced by the oil is clustered on the same page or part of a page shown with other engine parameter displays. This classification is shown in Figure 6 on a Garmin G1000 digital instrument display device for general aviation. The manifold pressure indicator in reciprocating engine aircraft shows the density of the air in the induction pipe of the engine. It is a reflection of the engine's evolving power as the pressure with the fuel-air mixture is directly proportional to the engine power [3]. It implies an indicator below atmospheric pressure is the limit for normally aspirated engines. Turbocharged and overcharged engines compress the air being blended with the gasoline, thus suggesting maximum power above atmospheric pressure [5]. Numerous multiple pressure gauges are measured in inches of mercury while digital displays can have the option of projecting on a different scale. A traditional analog gauge uses an aneroid with the attached pointer showing the actual air pressure as the ambient pressure is operating on the aneroid within the scale [3]. A column extending from the inlet manifold via the gauge demonstrates the pressure from the inlet manifold to the aneroid so that the gauge shows the total pressure in the intake collector. Over the engine mechanisms is the Garmin G1000 multipurpose demonstration in Figure 6, the digital visualization of manifold pressure. The operational document of the aircraft provides detailed information on the control of manifold pressure for fuel circulation and pitching of the propeller with the development of various output profiles during distinct stages of flight and run-up [3]. Figure 7 displays an analog spherical pressure gauge together with its internal operations. A type of multiple pressure monitor with reference dial for mercury (Figure 8). The engine of the turbines possesses its pressure signal that corresponds to the power the engine is generating. It is called the measure of a ratio of the engine pressure (EPR). This gauge relates overall exhaust pressure to ram air pressure at the engine inlet. The EPR gauge gives an indicator of the thrust being produced by the engine, with adjustments for temperature, altitude, and other variables. As the EPR measurement instrument associates the dual pressures as it is adopted as a gauge for differential pressure. As a remotely sensed device that derives its feedback from the transmitter of the engine pressure ratio or a device while viewing digital instrument systems. The maximum pressure transmitter is equipped with the bellows mechanism that contrasts the two pressures which transform the ratio directly to the electrical signal that is received by the gauge [3]. The pilot is also equipped with sensitive information by fuel pressure gauges as fuel is usually pumped to the aircraft through separate fuel tanks to the engine. A defective fuel pump or tank depleted beyond the point where enough fuel reaches the pump to sustain the required output pressure is indeed a situation with urgent attention from the pilot. While there are direct fuel sensing pressure gauges with Bourdon tubing, protective layers as a diaphragm and bellows detecting frameworks, operating a fuel line directly to the cockpit are especially unwelcome, due to the possibility of fire outbreak in the case of leaking. The alternative solution, therefore, is to allow whatever sensing system is used to be part of a transmitter unit that uses electricity to conduct an indicator to the cockpit. Often fuel flow control signs are used in place of fuel pressure gauges [3]. On complex aircraft, several pressure measurement gauges are now used to show the state of the specific support systems that are lacking on light aircraft. Hydraulic structures are frequently applied for lowering and lifting the landing gear, working flight controls, braking [3]. The normal operation of the hydraulic devices requires adequate pressure that is needed within the hydraulic system established by the hydraulic pump(s). The pressure of the hydraulic gauges is mostly positioned at the cockpit and at or around the airframe service center of the hydraulic

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 4, Issue 8, August – 2020, Pages: 316-322

mechanism. Remote indicators with maintenance workers are often read directly with the Bourdon tube sensors. Cockpit gauges generally possess system pressure communicated electrically from sensors or computers. Figure 9 displays a hydraulic pressure device in a hydraulic system of a high-pressure aircraft. The gyro pressure, vacuum, or suction gauges are features for similar measurements to control the vacuum created with the device that activates the gyroscopic aircraft systems powered by air. The instruments draw air, allowing the gyroscopes to spin where the rate at which the gyros spin must be within a given range for proper operation. This pace is related directly to the pressure gradient that is produced in the system. The suction indicator is crucial in aircraft focusing entirely on the vacuum powered gyroscopic flight instruments [3]. The vacuum naturally becomes a gauge for the differential pressure, implying the pressure is contrasted to atmospheric pressure with the use of a sealed protector. The mercury scale is configured in inches as it indicates how much pressure in the system is compared to that of the atmosphere [3]. In aviation, merely monitoring whether the pressure generated by some other operating mechanism is either high or reduced is usually balance, such that resolution can take effect whenever any one of these circumstances occurs. This is often solved with the use of a pressure release. The valve regulator remains a basic tool normally designed for opening or closing an electrical circuit when a certain pressure in a system is attained. This can be generated as the electronic signal is generally open and can then be closed if a certain pressure is detected. Alternatively, the circuit loop can be disabled and afterward activated when the activation pressure is achieved [3]. Pressure switches have a covering called diaphragm with one end to which the detected pressure is applied. A mechanical switching system with the electrical systems attached to the other part with the diaphragm. Minor deviations or pressure formation contrary to the diaphragm relocate the diaphragm, but never active to flick the switch. The diaphragm only covers the mechanical section by the opposite direction controlling the switch connections with the circuit connections as the pressure encounters or surpasses the switch structure. [Figure 10]. Nonetheless, with a specified pressure, the individual switch is programmed to close and open as they are mounted in the appropriate position.

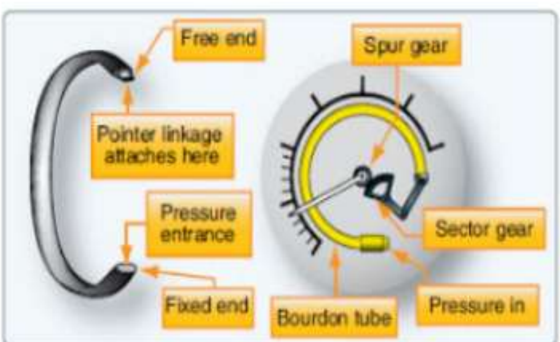

Figure 1.The bourdon tube

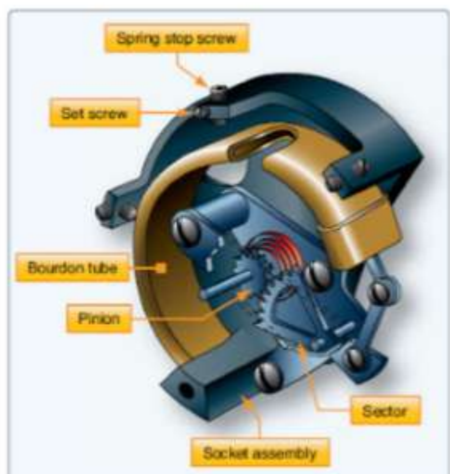

Figure 2. The bourdon tube mechanism

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 4, Issue 8, August – 2020, Pages: 316-322

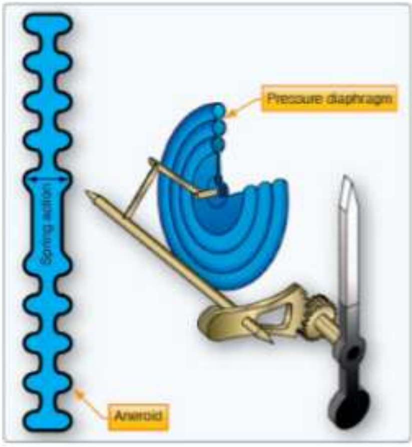

Figure 3.Aneroid diaphragm

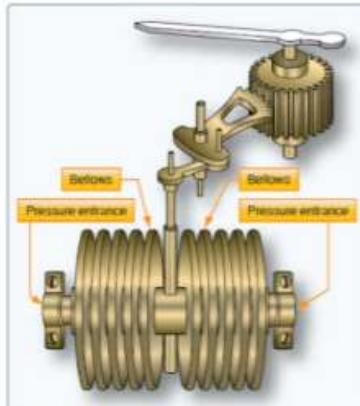

Figure 4.Bellows (Differential pressure gauge)

Figure 5.Analog pressure gauge

Figure 6.Oil pressure indicator at cockpit display panel

Figure 7. Engine pressure ratio gauges

Figure 8.An analog manifold pressure indicator

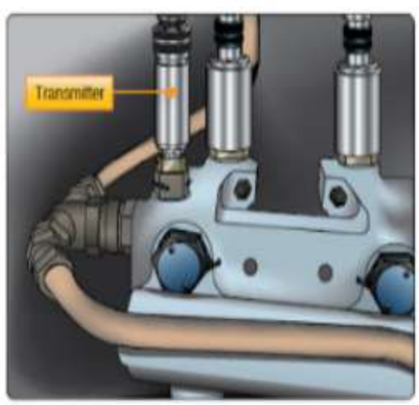

Figure 9.Hydraulic pressure transmitter

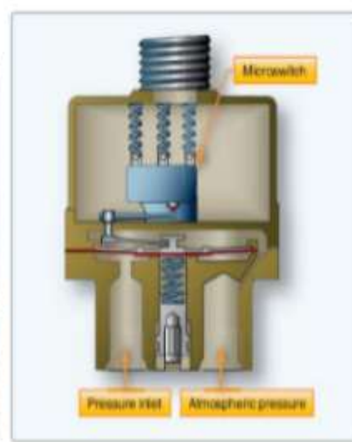

Figure 10. Pressure switch

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 4, Issue 8, August – 2020, Pages: 316-322

Aviation Altimeter pressure settings

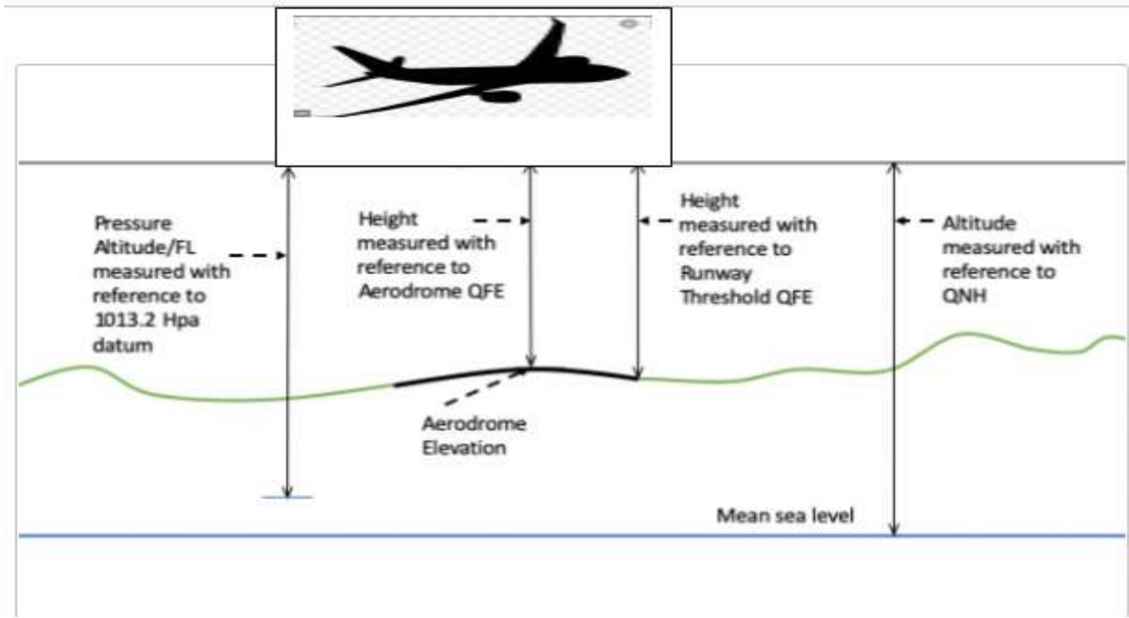

Figure 11. Categories of aviation pressure settings

QNE is unique from several types of altimetry code Q that does not represents a pressure point. With the configuration of the Standard Pressure of 1013.2 mb, an aircraft altimeter demonstrates Pressure Altitude (Flight Level) as applied by most aircraft operating against the conversion level to declare a standard vertical measurement results. Regular pressure according to International Atmosphere Standard (ISA) relates with the air pressure at mean sea level (MSL) [6]. QFE at reference point is the isobaric surface pressure as the altimeter provide an interpretation of the altitude over the point of reference at certain altitudes. As the QFE aerodrome at the subscale, the altimeter shows zero at the widest position over the runway, and the height just above altitude of the airspace is indicated at other high altitude. The QFE can be dependent on the maximum height [ICAO Doc 4444, 4.10.1.2] for exact access runways or for runways at which the threshold is 7 ft. or lower aerodrome level and with the QFE runway limit set at the subscale, offers the altimeter readings to be null at the runway limit. [7].

QNH is the pressure on the altimeter's subscale so that the detector reflects its distance above sea level. Once the air plane remains on the runway the altimeter can read runway level and the Airfield QNH is achieved through the correction of the calculated QFE with ISA irrespective of the atmospheric temperature condition. As the altimeter is configured by ISA, it will accurately signify the altitude only at point of reference as other altitudes are possibly to be inaccurate, based on the atmospheric temperature [8].

2.0 METHODOLOGY

An online interactive basic navigation simulators was adopted in the modelling of the pressure altitude (10 to 100 ft) against the indicated altitude at standard altimeter setting of 1013.25 hPa

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 4, Issue 8, August – 2020, Pages: 316-322

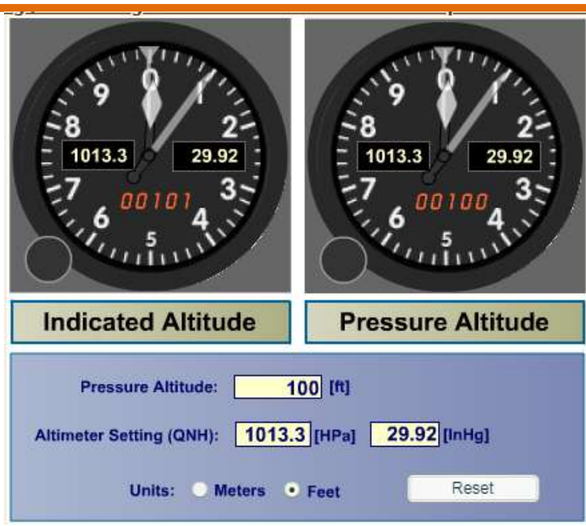

Figure 12. Altimeter simulator interface.

3.0 RESULTS AND DISCUSSION

Table 1.Output from the simulation of the indicated altitude with the pressure altitude

Altimeter setting (QNH) (Hecto pascal)	Pressure Altitude (feet)	Indicated Altitude (feet)
1013.3	10	0
	20	0.2
	30	0.3
	40	0.4
	50	0.5
	60	0.6
	70	0.7
	80	0.8
	90	0.9
	100	1

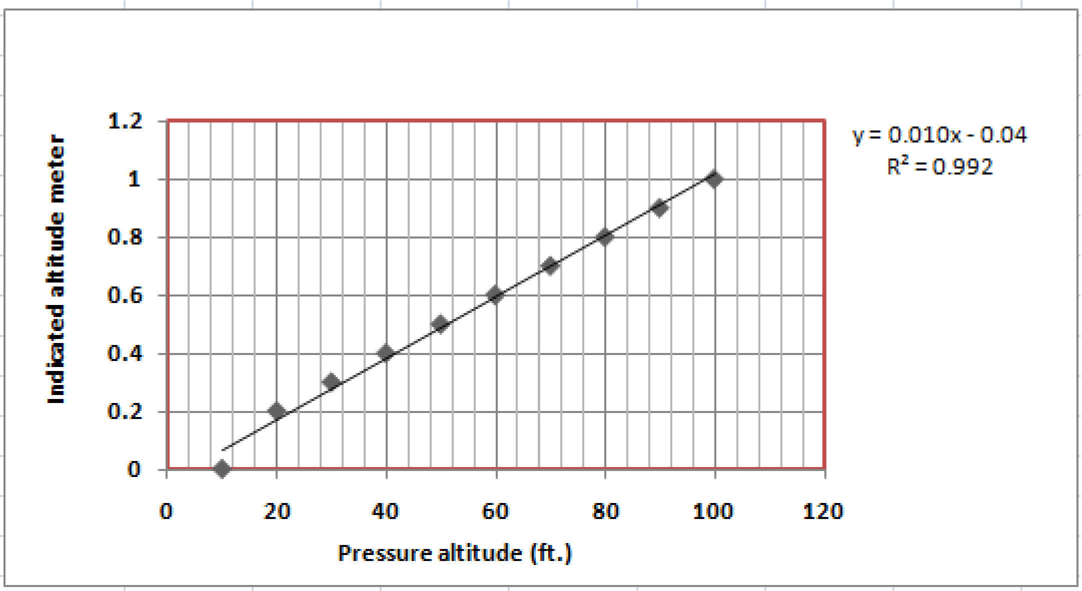

Figure 13. Linear relationship between the indicated altimeter altitude and pressure altitude in feet

The established relationship between these two flight parameters is clearly linear with the modelled equation of $y = 0.010x - 0.04$ with regression coefficient (R^2) of 0.9920. This technically implies that the expected altitude meter that will be displayed is a direct function of the altitude induced by the atmospheric pressure.

4.0 CONCLUSSION

Flights operates under diverse atmospheric conditions and therefore demand a suitable technical model(s) and theory (ies) that will empower and enhance their optimal performance. This is can be achieved by designing an atmospheric framework that predicts the mean specific conditions in a given situation. Hence, the pressure exerted by the atmosphere against the airplane was considered a dependent parameter with direct correlations on the indicated cockpit altimeter.

5.0 REFERENCE

1. Db0nus869y26v.cloudfront.net. (2020). https://db0nus869y26v.cloudfront.net/en/Pressure_altitude.
2. Pressure altitude explained. Everything.explained.today. (2020).http://everything.explained.today/Pressure_altitude/.
3. Instruments, A. (2020). Aircraft Pressure Measuring Instruments. https://www.aircraftsystemstech.com/2017/06/pressure-measuring-instruments.html.
4. Atmospheric pressure | Definition & Variation. Encyclopedia Britannica. (2020). https://www.britannica.com/science/atmospheric-pressure.
5. Training, A., Maintenance, B., Schools, A., Books, A., & Systems, A. (2020). Pressure Instruments (Part One). Flight Mechanic. https://www.flight-mechanic.com/pressure-instruments-part-one/.
6. Instrument Flying Handbook - PDF Free Download. epdf.pub. (2020).https://epdf.pub/instrument-flying-handbook.html.
7. Altimeter Pressure Settings - SKYbrary Aviation Safety. Skybrary.aero. (2020). Retrieved 26 August 2020, from https://www.skybrary.aero/index.php/Altimeter_Pressure_Settings.
8. Philip Thomas (2019).Altimetry: QNH, QFE, QNE, QFF, SPS. https://philipthomas94.wordpress.com/2019/02/07/altimetry-qnh-qfe-qne-qff-sps/.