COCKPIT WHITE BOX SYSTEM DESIGN FOR AIRCRAFT SAFETY MONITORING

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Abstract: This paper presents certain results of monitoring flight parameters such as speed, flight-level, direction and temperature which are automatically sent to the base station at Air Traffic Control (ATC). At present, the cockpit voice recorder (black box) used to record the audio environment in the Flight deck. This audio part examines only during the investigation of accidents and incidents. The proposed cockpit white box system automatically measures the flight parameters and transmit to the base station using GSM. The base station uses that information and provides guidance to the pilot on the potential for strong a storm, a hurricane, and a tornado. The base station can track the Flight using GPS and alert the pilot in critical condition. The pilot can take safety measures such as path diversion or a safe landing.

IndexTerms **-** Flight parameters, Air Traffic Control, GSM, GPS, Cockpit white box.

I. INTRODUCTION

The paper "Cockpit White Box System Design for Aircraft Safety Monitoring" aims at monitoring various parameters like speed, flight level and temperature of the aircraft simultaneously. This is achieved with the help of sensors, GPS and GSM module which is controlled by PIC microcontroller. The analog input from the sensor is converted to a digital signal by an analog to digital converter and give it to the PIC microcontroller. The encoded data is transmitted and received through the GSM Module. The received signal is decoded and the data are given to the base station microcontroller as inputs. Global Positioning Satellites (GPS) is used to track the flight position accurately and provide their real-time positions to the base station over the GSM link. The output of PIC microcontroller is fed to the PC. In PC, the Geospatial analysis tool and Geographic information system are used to track the path of the flight in the map. The white box Geospatial Analysis Tool (GAT) is an open-source Geographic information system (GIS) software which is used for remote sensing [1]. The GIS package is a user-friendly graphical user interface (GUI). The speed, flight level, and temperature of various machines are monitored from the base station. If there is any drastic change in the Flight parameters it could be known from the base station and necessary instruction can be provided to the pilot. The whole system which deals the tracking of aircraft from the base station with the information directly collected from the aircraft cockpit. The details will help the base station for taking necessary action at the right time. Black box only helps the investigators during accident investigation [2]. GPS interfaced system can immediately drive the rescue teams to the spot at the right time even though an accident occurs. Hence the system is termed as the newly proposed white box for tracking and monitoring the aircraft.

II. COCKPIT WHITE BOX SYSTEM DESIGN

2.1 Flight Deck Pilot Area

PIC16F877A is one of the Microcontrollers from PIC Micro Family microcontrollers. PIC microcontrollers comprise a reduced set of simple instructions. Because it uses the RISC (reduced instruction set computer) technology. Simple instructions are processed faster than complex instructions. The main advantage of RISC technology is based on this fact. The following features are considered for the system design, the device should be flexible, consume low power, handling easy where microcontrollers had not previously been used. The functionality of microcontroller can improve by incorporating some basic functions inside the microcontroller. Some of these basic functions are comparator A/D converter, RAM/EPROM memory, PWM, internal clock, serial communication, flash memory and programmable I/O. Some microcontrollers help to incorporate all of these functions in one single chip.

PIC16F877A is a 40 pin integrated circuit with 35 instruction words to learn [3]. All the instructions are executed in single-cycle. Program branches are exceptional, which are two-cycle. If operating speed is 20 MHz, execution time will be 200ns. Which means 5 million instructions are executed per second. 256 x 8 bytes of EEPROM Data Memory, 368 x 8 bytes of RAM, 8K x 14 words of Flash Memory are the special features of this high-performance RISC machine. Re-programmable Flash memory is used for program storage. High current Input/ Output ports (with pin direction change) let the system communicate with the outside world. So the system can control the output connected with the right interface. PIC microcontroller has up to three timers that you can either use as a timer or a counter. The on-chip RS232 protocol, I2C and SPI Interfaces, Capture/ Compare/ PWM module, ADC, programming using ICSP are some of the useful features of PIC microcontroller [4].

Figure 1 shows the block diagram of the Cockpit White Box system design for aircraft safety monitoring. The sensors incorporated with the system helps to measure the various flight parameters like temperature, the speed of the flight, altitude, latitude, and longitude. Temperature is measured by using temperature sensor LM35. The Slot sensor HOA1877 series used for speed sensing. The sensor for measuring speed should fix with the rotating parts of aircraft such as a propeller. Pressure sensors are

normally used to get the idea of altitude. The pressure sensor is employed because the pressure and altitude have a relation in nature [5].

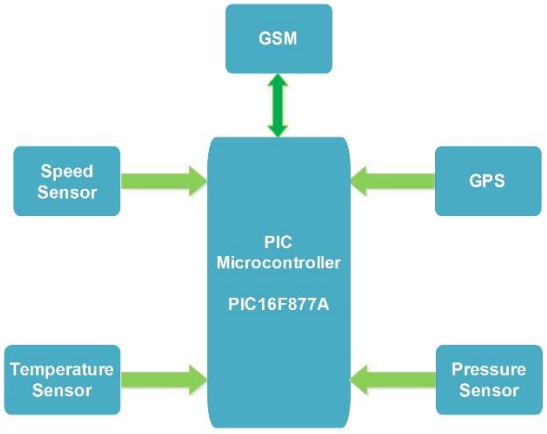

Figure 1. Block Diagram of Cockpit White Box System Design for Aircraft Safety Monitoring

The output voltage of LM35 (precision integrated-circuit temperature sensors) is linearly proportional to the Celsius temperature. This is used to measure the surface temperature of the flight or the temperature of the engine. According to the requirement, ones can implement the sensor. At room temperature, the LM35 is not required any external components to provide accuracies of ±1⁄4°C and ±3⁄4°C over a full temperature range −55 to +150°C [6]. The interfacing of LM35 to control circuitry is easy because it gives linear output with low output impedance inherent calibration. It can be worked with a positive or negative power supply with plus and minus supplies. LM35 has low self-heating, less than 0.1°C in still air. It draws only 60 µA from its supply. The LM35 is designed to operate over −55° to +150°C temperature range [7]. The temperature sensor frequently senses the heat energy and produce equivalent voltage. The output voltage is directly fed to the controller.

The HOA1877 series integrated circuit consists of an infrared emitting diode and an NPN phototransistor or photo Darlington where are enclosed in a black plastic housing. The detector switching takes place whenever an object passes between the emitter and detector. IR transmitter and receiver are there in slot sensor. A light is passed between the IR transmitter and receiver continuously. It is interrupted by the DC motor. When it is interrupted, PIC counts the number of interruptions occurred which is considered as the speed of the engine and it is digital in nature.

Based on the measurement of atmospheric pressure Altitude can be determined. Altitude and pressure are inversely proportional. A pressure altimeter is a kind of altimeter found in most of the aircraft. The calibration of an altimeter follows equation [8]:

$$A = C\, T_a \log (P_s/P_r) \quad (1)$$

Pr is the pressure at altitude A, Ta is the absolute temperature and Ps is the pressure at sea level. The constant C depends on the molar mass of the air and acceleration due to gravity.

The Global Positioning System (GPS) provides navigation, reliable positioning, and timing services as shown in figure 2. The system with a GPS receiver provides an accurate location and time information anywhere in the world for all weather, day and night. GPS Receiver used to get the location information from satellites. It is in the form of latitude and longitude. This is done with the help of the GPS satellite. The receiver uses the information to determine the transit time and computes the distance to each satellite using the speed of light [9]. With the help of navigation equations, these satellites locations and distances are used to compute the location of the aircraft. The GPS module is attached to the aircraft which needs to be identified. The GPS antenna connected in the GPS module receives the information from the GPS satellite. GPS system is essential to provide data of ground speed, heading, and position of the Airbus. In order to include GPS data into the system, serial communication is used. The majority of the portable GPS units has a built-in serial port and uses the NMEA0183 protocol. The GPS send data through the serial port at a baud rate of 9600bps.

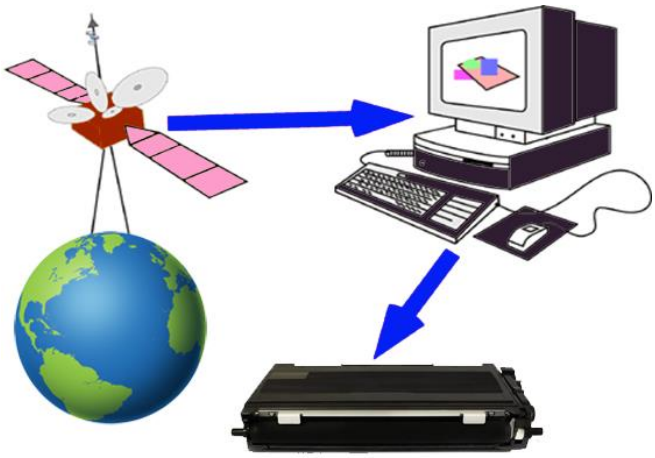

Figure 2. GPS Location Tracking

Global System for Mobile Communications (GSM) is a standard protocol developed by European Telecommunications Standards Institute (ETSI) for digital cellular networks. The standard GSM was developed as a replacement for first generation analog cellular networks. GSM is capable of full-duplex digital voice telephony. The GSM standard networks operate in various carrier frequency ranges. 2G GSM networks operate in 900 MHz or 1800 MHz bands. A wide range of baud rates GSM modem supports from 1120-12000 [10]. This cannot send data using a higher baud rate. While transmitting USART as higher baud rate require higher clock rate which is not available on board. AT commands are used to control the modem. Figure 3 shows that the software algorithm for receiving information on flight parameters over GSM technology.

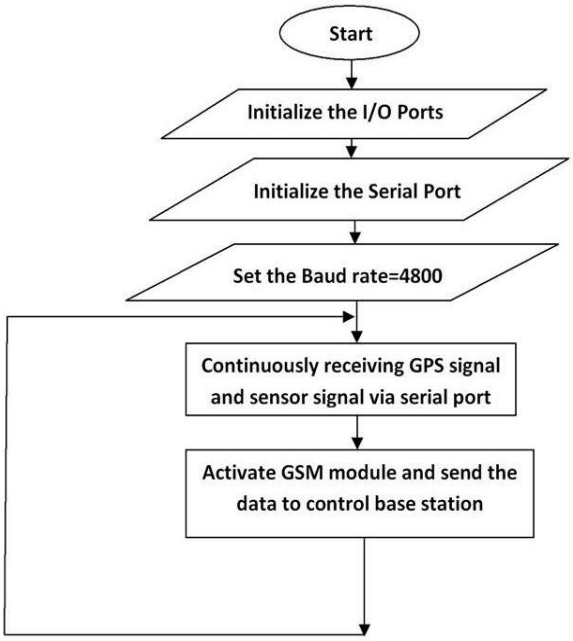

Figure 3. Software Algorithm for Cockpit White Box System Design

2.2 Base Station Flight Monitoring Area

The base station of flight monitoring system shown in figure 4 includes a GSM modem to receive the data and a microcontroller. The received data converted into a read file and constantly supplied to a personal computer. This station creates a database with readily available data and works as a black box [11].

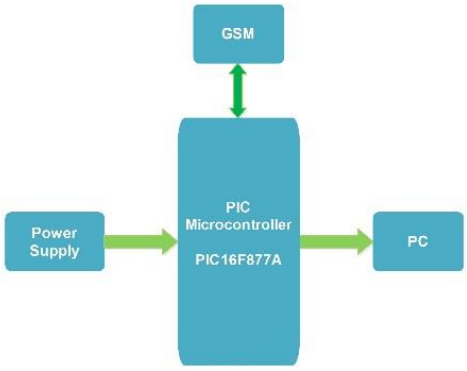

Figure 4. Base Station Sub-System Design

2.3 GIS Software Uploaded Display Unit

A Geographic Information System (GIS) is a system designed to capture, store, handle, analyze and present all types of geographic data [12]. By understanding geography and location ones can make an intelligent decision. A good GIS program has the ability to process geographic information. Often the map file databases are included with GIS package. The altitude, latitude, and longitude information are received using GPS from the cockpit which is integrated with the GIS to identify the exact position of aircraft. GIS maps are highly visual and more interactive. The map user can scan a GIS data in any direction on the screen and can do zoom in/out, and can change the nature of the information in the map.

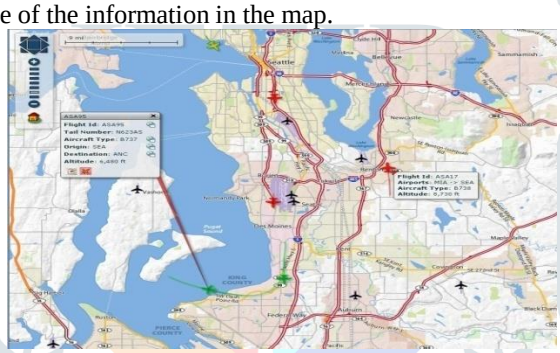

Figure 5. GIS Based Flight Tracking

The GIS program shown in figure 5 is designed to perform calculations for tracking storms or predicting erosion patterns and etc. In critical condition, the base station can suggest necessary action to the pilot by monitoring the flight parameters and position.

III. Conclusion

Aircraft monitoring and tracking are used for ensuring flight safety. If something happened incorrect air during the flight travel, mass destruction will occur in both money wise and people wise. In order to take safety measures, flight parameters are constantly monitored from the base station. The position details such as latitude and longitude are measured by using GPS. The flight parameters available at the base station are converted as a read file and maintain a database. Thus the read file act as a black box. The flight path can simultaneously track on PC in which GIS software works. The software platform supply adequate information about the feature of the area where the flight located. The tool available in the platform is capable to guide in case an emergency or crash landing required. Incorporating the weather monitoring system it can also possible to predict the bad weather condition. The drastic change in the sensor measured values also can tell the change in weather or flight condition. To avoid the risk of the journey, the pilot can receive feedback from the base unit. The system not only recording the history of the journey (black box) but also helps to guide the pilot in an emergency condition. This additional features ensuring the safety of aircraft with simultaneous monitoring and thus proposes a new system of cockpit white box.

IV. Acknowledgment

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