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An Aircraft Health Monitoring System using IOT

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Abstract

Objectives: we are propounding an Aircraft health monitoring system using IOT. Which will send the health status in real time to the base station and also predict product reliability**. Methods/Statistical analysis**: Basically we are replacing a black box in an Airbus with this system which continuously sends all the parameters read and computed by the sensors on board to the base station using IOT. It helps to make better decision in critical conditions and to keep record for further analysis. This system will also predict life span of an electronic device by using prognostic health management method**. Findings**: This study results in an effective system which is more reliable, economical and secured as much as internet since the IOT platform is used. The propended system measures the health status in real time the same will be updated to webpage. **Application/Improvements:** The proposed system can be improved by using high speed and reliable internet connection in aircraft and by using wireless sensor will give better efficiency and reduced weight.

Keywords: Black Box, Flight Test Instrumentation, IOT, Prognostic Health Management, Wireless Sensor Network

1. Introduction

In aerospace, health management systems[1] are heavily used for monitoring and to control the condition of various on-board electronic devices, identifying service interferences, checking for critical and non-critical parameters (i.e. temperature of both engines and cabins, vibration of wings and wheels, cabins' pressure, fuel consumption, and so on), to prevent dangerous effects[2]. Using Fly-by-wire technology for air vehicle, aircraft flight controls have resulted in better performance and reliability. And also reducing in control system weight[3]. Avionics is a fundamental of the flight management and engine control of present air vehicles**.** Increasing in on board complexity and autonomous devices will lead to more critical factors that have to be taken care. This increasing the demand for the health monitoring at different levels in aircraft. Health monitoring can be done by deploying number of sensors on board and collecting the parameters read by them and analyzing the health status and also predicting life span of an electronic device.

In conventional health monitoring of a commercial airbus will use Black Box, which keeps the record of the parameters read by on board sensors. This information is only available when the airbus is at ground. In case of fighter jet the Flight Test Instrumentation (FTI) is used for the first flight. Which consists of different LRU's (Line Replaceable Units) that includes power supply unit and a user electronics interface unit. The power supply unit consist of electronic circuits to generate power, converting and, conditioning the power generated. The user electronics interface unit consist of integrated circuits such as Programmable Logic Devices (PLD), memory, input and output units, Central Processing Unit, etc. The FTI data is tested to analyze the health status and working status of LRU's. So we propose an IoT based system[4], which sends all the information to the base station in real time. This makes it easier and better in decision making.

IoT can be defined as the communication between objects that are enabled with internet connectivity with a unique IP address. IoT provides low power, long/short range communication. It also gives efficiency over use of data to improve decision making. Innovations of IoT will leads to rapid improvement based on real world performance and this is cost effective comparatively.

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An integrated system health management for aerial vehicle software system was proposed to give assistance in avoiding catastrophic software failure by predicting failure, providing warnings and ongoing reliability monitoring as well[5,6]. Prognostic health management methodologies allow estimate on prior damage in deployed electronics by interrogation on depending on damage proxies. The data is collected for leading of failure for alloy, inter-connects under the application of Isothermal load, a non-linear least square algorithm is used for determining prior damage history[7]. Use of fly-by-wire method in avionics has given better performance, reliability, reduced weight and also resulted in more intelligent control systems[8]. Using WSN may lead to increase in total sensors, can improve critical and non-critical parameters and also leads to system prolixity and results in reduced aircraft weight and complexity[9]. The WSN network architecture is suitable for structural health monitoring. The main aim is to detect flutter phenomenon along the wings and communicating this to cockpit to react before vibration turns to resonance[10,11].

2. Technology Implemented

FTI- Flight Instrumentation Test is the system used for health testing in fighter jets. This system is used before certifying the aircraft to use and also in case of any update is done to the aircraft. The data acquisition system used in FTI is shown in Figure 1.

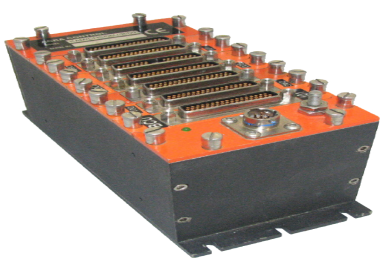

Figure 1. KAM500.

The FTI keep track of RALDT (Radar Altitude), OSAMC reset pin (Open system Architecture for machine computer), HOTAS (Hands on throttle and stick), INGPS (Inertial global positioning system), Angle of attack, Impact temperature (0'c-1000'c), Static Pressure (0-1100 mili bars), Differential pressure, Relative humidity (65-80%), Engine rpm (4200 impulses per min). The sensors data will be in analog, digital and mil bus and is stored in data acquisition system KAM500 and data is converted to telemetry format and sent to the base station via telemetry antenna. The telemetry receiver in base station will demodulate and convert the data to the original format and stored for the analysis. The complete block diagram of FTI is shown in Figure 2.

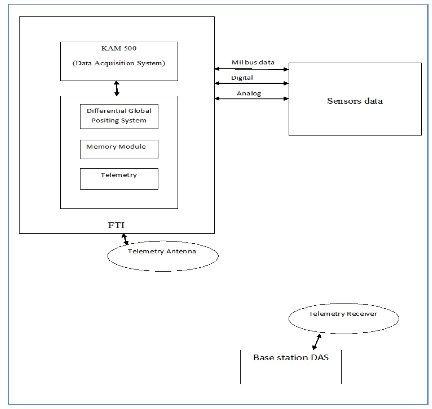

Figure 2. FTI Block diagram.

3. Problem Formulation

Aircraft designers are intently looking for COTs (Commercially Off-The shelf) electronic components and sub systems. Since increasing in deficit of military qualified electronic components and to take benefit of high performance with new technologies like low voltage, low-k dielectric, copper interconnect etc. the needs of commercial electronics do not have long product life or supportability. Therefore the industries such as military and avionics are at risk from life limited electronic components.

The aircraft consist of several electronics subsystems such as for communication, navigation, flight control, environment control, collision avoidance, engine control etc. The reliability and health monitoring is necessary for in safety and active working of an air vehicle. In considering this situation, we design a Health monitoring system for aircraft based on IoT. That will have a number of sensors such as Temperature, Pressure, Relative humidity, Nose wheel steering sensor, Rudder pedal sensor, Pilot's stick sensors, Fuel level, Acceleration sensors etc. deployed on board which keep recording the parameters and are read by a computing device and send to the base station via IoT. The data is maintained and stored for predicting the health status of electronic device using prognostic health management method.

4. Wi-Fi Implementation in Aircraft

There are mainly two ways to create Wi-Fi in an air vehicle.

- Air to ground
- Satellite based

4.1 Air to Ground

Gogo is the top and best network provider of this type of service. It has been implemented on over 1,000 air vehicles operating on most routes in the U.S., such as Delta, American. By using ground cell tower network throughout the U.S. continental (therefore does not work over water). These towers coverage cells are much bigger than those of the normal mobile towers used by other service provider. This use a version of CDMA, just like Verizon cell phones. Antenna is placed on the belly of the airplane, looks like a small fin. This network implementation cost is much cheaper than satellite based implementation. The accessible bandwidth is a few megabits per second per aircraft. Figure 3 shows the gogo network architecture.

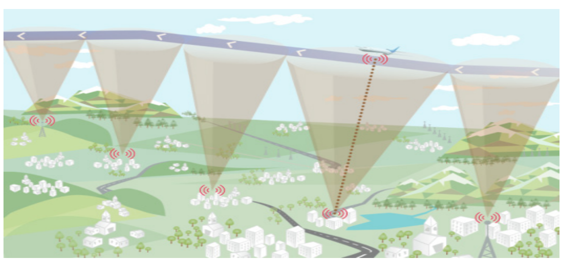

Figure 3. GoGo network coverage.

4.2 Satellite based

There are three types: L-band (e.g. Inmarsat Swift Broadband), Ku-band (e.g. Panasonic, Row 44, and Gogo (2015)), and Ka-band (near future, satellites launching soon). These bands represent fixed frequency ranges for data transmission. L-band is little slow, maximum 422kbps per channel per airplane. Ku-band is highest among around 20-40Mbps per aircraft, Ka-band provides even more speeds. The Speed of data transmission relay the number of aircrafts in the satellite's transponder "footprint" (aka spot beam) 2KU, Gogo's new technology, make use of two Ku-band antennas, one for band is downloading and another band for uploading. The architectural view of satellite communication is shown in Figure 4.

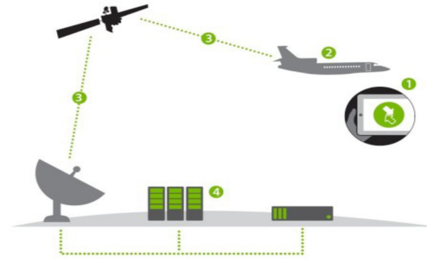

Figure 4. Satellite based network.

4.3 The LOON'S Technology

Balloons are used for many purposes but here it is used to create internet connection in remote or isolated areas. In this project network is created by making large balloons floating in stratosphere. Which act as a wireless station and provides internet service to the isolated areas in a cost effective manner[12].

5. Proposed System Working

The numbers of various wireless sensors are deployed in an aircraft to monitor different parameters, such as temperature, pressure, fuel level indicator, accelerometer, RADALT, nose wheel sensor, pilot stick sensor, motion sensor, Ailerons sensor etc. The sensors will keep track of the scenario and record the parameters and sent to the interfaced computing microcontroller. The use of wireless sensor will lead to reduced weight and less complexity of controlling system. Now the computed data is fed into the web page through IoT. The cockpit display may have webpage or GUI to see these parameters. Due to IoT we have all the parameters read by sensors at base station in the web page. These data to be stored in the server or memory module for further analysis of time to failure of a LRU or a device. Since we have the real time data of aircraft health in case of bad weather and failed communication through radar, the base station authority can guide the aircraft through IoT by analyzing the available read parameters.

6. Predicting Product Reliability

There are mainly two types in analyzing product reliability. One by predicting time to failure (Data driven approach) of a device and other is by checking the critical parameters (Model driven approach) which may lead to crack or delaminating. No electronic device will have unlimited life span so certain devices need to be replaced after fixed duration of time for safe flight. Data base is created such that it should display a message asking for the replacement of device in certain interval of time predict on the basis of its time to failure. The time to failure of a device is predict with its history of failures in the stored data base. We will also set a certain critical level for all parameter after which the warning message will be displayed in cockpit display. For example if u keep on increasing the acceleration for an engine beyond its range the vibration will occur and that may lead to resonance. The resonance will disturb the structural health of the air craft. Figure 5 shows the flow chart of predicting product reliability.

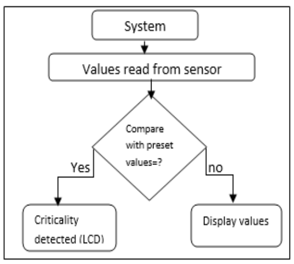

Figure 5. Flow chart of predicting product reliability.

7. Experiments and Results

The ARM LPC2148 microcontroller with LM35 temperature sensor, humidity sensor, Accelerator, DC motor and GPS along with IoT module ESP8266 are used. The microcontroller will accumulate all the values from sensors and update it to the IoT web page. The ESP8266 is a Wi-Fi module that supports IEEE 802.1 internet standard. The internet of things web terminal is created by creating a channel in www.tingspeak.com. The thingspeak is an open source webpage for internet of things. There are critical levels are set for all the parameters, if the readings go beyond that than a warning message will be displayed in webpage. The reliability check can be either data driven or model driven. The basic block diagram of implemented solution is shown in Figure 6. The hardware connections and set up is shown in Figure 7. Figure 8 is the graphically represented data in Thingspeak Application.

8. Conclusion and Future Scope

We have proposed an IOT based aircraft health monitoring system. It monitors the conditions of components and reports to ground station via IOT, which is in real time and helps to take decision in critical situation. At the ground station the data is neatly organized date wise in Database. The data base can be used for future analysis. Analytical system which can predict the life time of components based on the monitored values is implemented at the IOT control terminal.

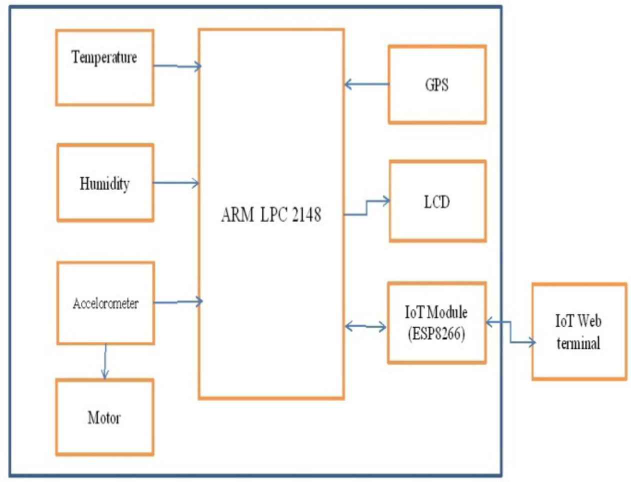

Figure 6. System architecture.

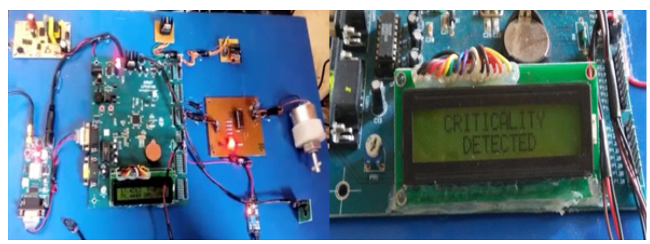

Figure 7. Hardware model and warning message displayed.

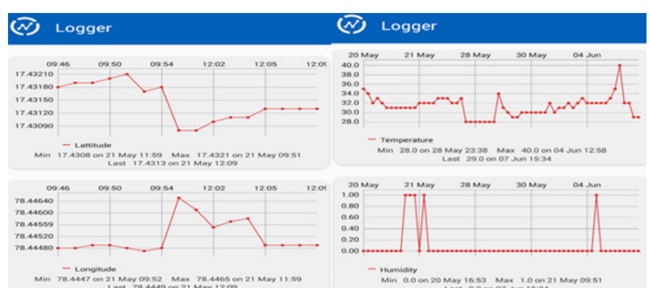

Figure 8. GPS readings, temperature and humidity in Thingspeak app.

By the use of wireless sensor network the weight of prototype can be reduced and which is also helpful for avionics and flight control. The wireless network sensor will also reduce delay and give more efficiency.

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