Volume 3 No.4, April 2013 ISSN 2224-3577

International Journal of Science and Technology

http://www.ejournalofsciences.org

Post Landing Automated Guidance System of Commercial Aircrafts using Infrared Beacons

Muhammad Ishfaq Javed [1], Salman Afghani [2], Junaid Shabbir [3]

[1,2]Army Public College of Management and Sciences (APCOMS)Rawalpindi, Pakistan

[3]Prozen Ltd., Flat 1, 999 Warwick Road, Acocks Green, Birmingham, B27 6QJ, United Kingdom

ABSTRACT

Nowadays technology is moving toward automation which reduces need for human in the production of goods and services, hence which reduces the human related errors and increases the efficiency of work. At present, on commercial airports taxiing technique is used to move airplane between the parking area and the runway, similarly marshalling techniques and Follow me Car is also using. In this paper we will discuss the design, development, implementation and modification of a cost effective and efficient guidance system for commercial airplanes, this system is based on the microcontroller and sensors which guide the airplane throughout the ways between the parking area and the runway. The developed model of small size airplane successfully worked in different indoor and outdoor environments.

Keywords: *Airplane, Radio beacons, Airplane tracking, IR tracing, IR communication, IR detection.*

I. INTRODUCTION

Guidance systems are of many types based on different technologies, satellite is main source of guidance system similarly GPS is also implemented system to guide on the ground. Rocket and missile guidance system are also available which guide the missile to hit the targeted area with accuracy. Guidance system for vehicles on the road or for parking is now a popular mean for safe [13] driving and guidance [2,6]. Although all systems work on radio waves but each system work in different radio spectrums. Guidance system for airplane is necessity of the time which guides the plane between the terminal and runway on the ground to get rid of taxiing, marshalling signals and follow me car. This automated guidance system is useful for airplane to guide the plane throughout the ways toward terminal, docking area or runway with the help of infrared beacons, hence it is totally automated so, need for human is not required to guide airplane ,hence there is no chance of human related errors which increases the efficacy of the system.

This guidance system based on tracking and communication of airplane with radio beacons; which guide the airplane. Installation on beacons is shown in figure1. Beacon is a guiding device which guide the objects, in this system we have used the Infrared beacon which guide the airplane with the help of infrared signals, infrared beacon is a bidirectional communication device which has transmitter and receiver in it, these infrared beacons are installed on the ground between the terminal and runway.

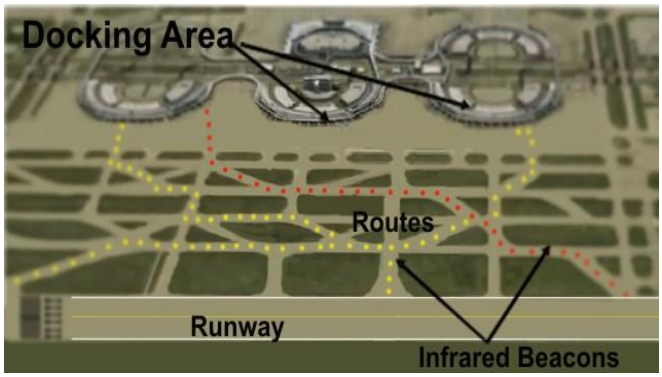

Figure 1. Installation of beacons and routes

The airplane has an infrared sensor installed in front of it near the landing [1,3,10] gear with a servo motor which is rotating 180 degree horizontally to track beacon. As airplane sensor track the beacon it starts moving towards that beacon, as it reaches the tracked beacon it again track the next beacon and hence it reaches the desired location.

An IR transmitter is installed in front of airplane which communicates with receiver of the radio beacon as airplane come closer to the beacon; this function of the communication is to turn the beacon on standby for some moments to indicate that the airplane has passed that beacon, as IR covers a lot of area and the range of each beacon overlap to each other. When the beacon turn on standby for some moment then the airplane sensor gets the time to search for next beacon, as it sense next beacon it starts moving toward it otherwise after one cycle of the servo it moves forward and searches again.

The aim of the research was to track the aircraft and guide it through the proper way without any error and with efficiency with help of infrared transmitter and receiver.

II. MATERIAL AND METHOD

A. Infrared Beacon

Infrared [9] beacon guides the airplane with the help of very narrow infrared beam, each beacon is consist of IR transmitter and IR receiver. The transmitter transmits infrared pulses modulated on 38 KHz where as the receiver is also capable of receiving 38 KHz infrared pulses only, the transmitter on beacon interacts with the receiver of airplane and guides the airplane.

Infrared beacon consists of two parts:

- the IR transmitter continuously keeps on transmitting signals of 38 KHz by IR diode, by this transmitter the tracker on airplane detect and sense the beacon and move towards it. IR transmitter is shown in fugure1.
- the IR receiver on the beacon is for communication purpose with airplane, the transmitter in front of airplane is set in such a way that when airplane come closer to the beacon the receiver on beacon interacts with transmitter of airplane which results to turn beacon on standby, meanwhile airplane starts searching the next beacon. IR Receiver is shown in fugure2.

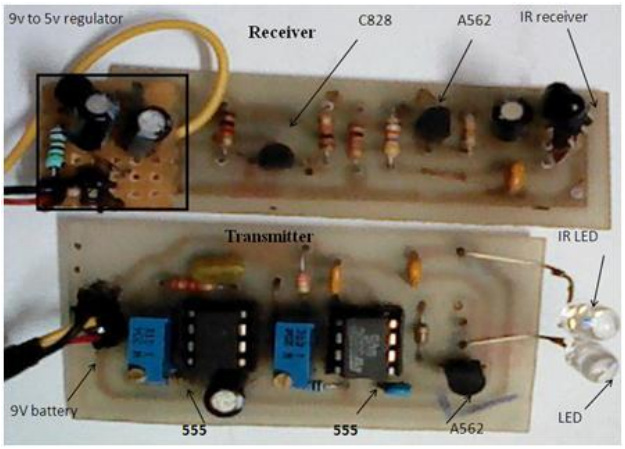

Figure 2. Transmitter and Receiver

B. Polarization and Sensing

Sensing is most important part of our project and also very sensitive part, sensing with help of infrared sensors is itself very difficult because of the sensors sensing area. IR have very wide aperture to receive or transmit the IR signals which made it difficult to sense from all the sides of transmitter and receiver, so it is required to polarize the sensors to communication from the front side only with narrow aperture.

In general IR transmitter or receiver has very wide operating area or there field of view is very large, hence polarization is requiring making the field of view line of sight. IR sensors sense the IR coming from all front directions. In our case we wanted that IR sensors should detect IR from specific region and reject the other which it could normally sense. For that purpose we have polarized our sensors. For polarization we use two different techniques named: polarization using aluminium tubes and polarization using aluminium hood (caps).

For polarization of sensors, first we use aluminium tubes. These tubes cover the photodiode of the IR sensor. The benefit of doing that the photodiode of receiver detect the IR only through the tube and as the tube path is narrow so the field of view of IR receiver got low. In our project we want that IR only detect the signals only in the line of sight so the aluminium tube in this case work very well. This polarizer is shown is figure 3.

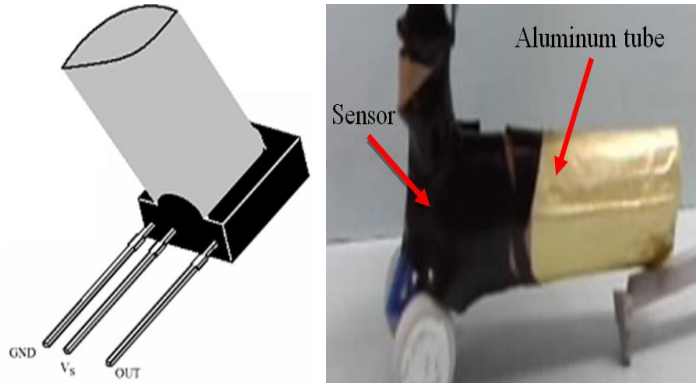

Figure 3. Transmitter and Receiver

As the results of polarization using tubes were not satisfactory in this case so we used aluminium caps. We wanted to make receiver which detect signals from transmitter in front of airplane, so vertical polarized receiver was required. The caps are designed such that they cover the IR sensor IC (Integrated Circuit) from front side and had an opening at photodiode side from where sensors detect the IR. The shape was chosen such that it is slanting from front to back so that IR sensor will detect the IR in vertical direction from large area. As we wanted different field of views in horizontal axis so by changing the width of the opening we achieved that. This process is shown in graph shown in figure 4.

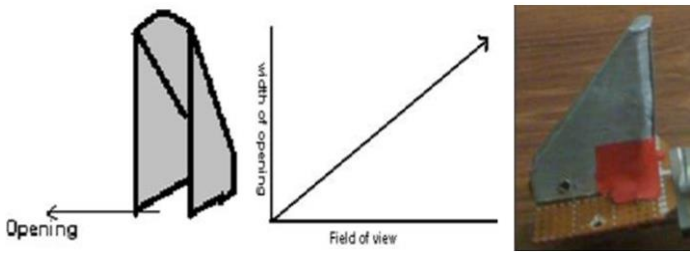

Figure 4. Aluminium hood polarizer

Sensing refers to detect the location of the beacons on the ground by sensor of the airplane. IR sensor is fixed with a servo motor attached in front of wheels of airplane, servo rotes 180 degree to track the transmitter of beacon once it detects the beacon the airplane starts moving toward that beacon. We used an algorithm technique of Single Eye Detection to track the sensor.

C. Single Eye Detection Technique

In this algorithm we used only one sensor to detect the location of the beacon on the ground. The sensor used is horizontally polarized such that it can only detect the IR coming from some meters region depending upon the environment. In this algorithm initially the servo is rotated such that the sensor searches for IR on the ground and when IR is received by the sensor then servo is stopped at that position and at the same time airplane starts moving toward the direction of detection. Servo stood still till the sensor receives IR. Whenever sensor stopped receiving IR servo motors start rotating again for the search of performer. Tracking of the sensor is shown is figure 5 and in figure 6 is presented Single Eye Detection flow chart.

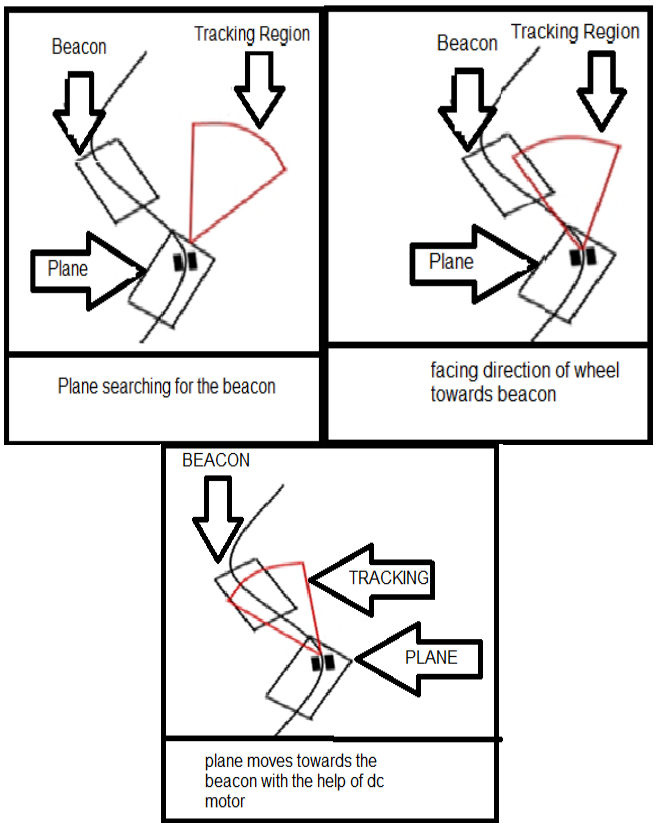

Figure 5. Tracking of the sensor

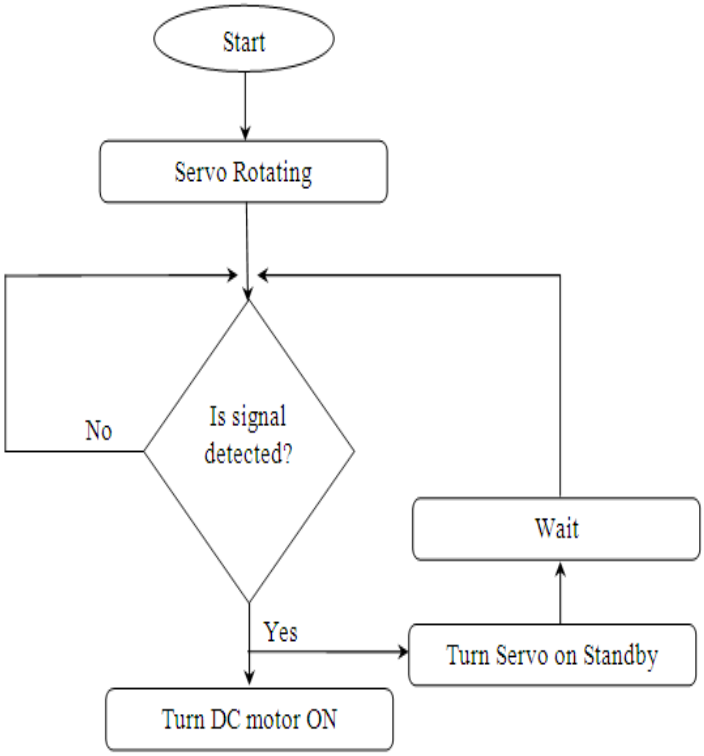

Figure 6. Tracking flow chart

The automated guidance system is designed such that when there is no IR beacon detected or simply when no IR detected servo motors rotates continuously in one direction then in other and hence the sensors attached to servo. This continues until an IR is detected. This is known as scanning mode. As there is only one sensor attached with servo which rotates with it until it gets IR, this process decreases the complexity of the system as if there is more than one sensor attached with servo motor to increase the scanning area, it creates synchronization problem for sensors. As all the sensors are attached side by side and hence their detecting area also overlaps to each other, it will create synchronization problems when sensor detects the beacon, since this system work better with one sensor.

By receiving the signals from beacon the airplane aligns its wheel toward the beacon and starts moving toward that beacon. If sensor stops receiving IR while moving it stops and servo again scanning the signal again until it gets signal. Figure7 gives a general overview about working of the whole system which is described in above text and algorithm follow by the system shown in figure6 in the form of flow chart.

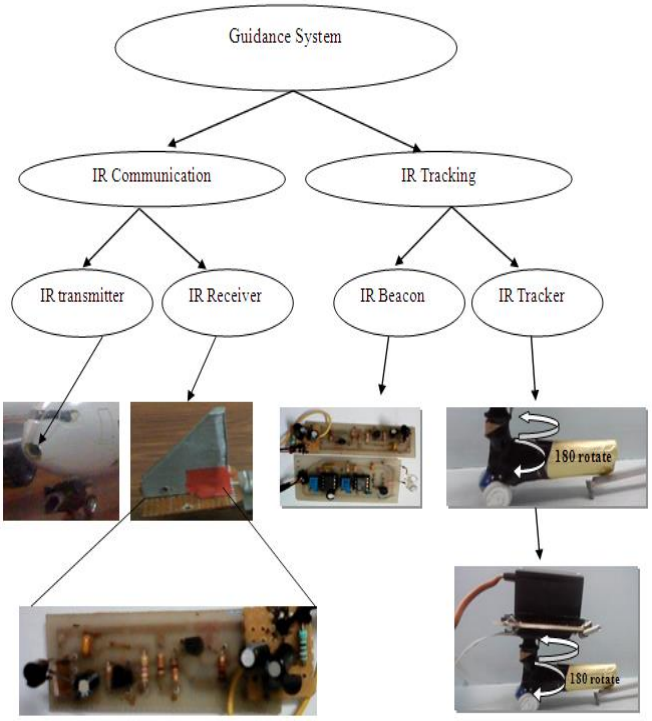

Figure 7. Working of complete system

D. Three Stage Network

This system consists of two microcontrollers which are responsible for controlling the sensing and generating the PWM for servo, these stages are named as:

-***Sensor stage***. The sensing stage consists of a ATM89C2051 microcontroller and a sensor attached with the servo with the wheels of airplane. This is first stage for the internal working inside of airplane, as the sensor receives the signal from beacon this system activates .as the sensor receives the signals it informs the microcontroller which then takes two actions ,activate the second stage and turn on the Power of airplane.

- **Servo Stage**. The servo stage is responsible for the movement of servo by controlling the PWM. This stage also consists of ATM89C205 microcontroller, the output of the sensor stage network in fed to this microcontroller if IR is detected at first stage ,which the stops the servo motor at the same time, if sensor is not detecting signals servo keeps on moving.

- **Regulator Stage**. This stage consists of a TIP 127 voltage regulator which regulates the overall voltages of the airplane and drives the DC motor of the airplane; it works on negative logic and connected with the first stage of sensor microcontroller, this is responsible to activate the DC power, as the sensor receives the signals it sends low signal to this stage which gets trigger and turns on the DC power.

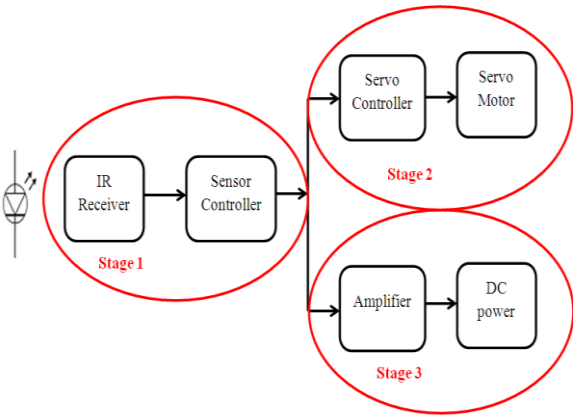

Figure 8. Three stage network

III. CONSTRUCTION

Now we will a look on how this system works using microcontroller and beacons and how it is constructed. The assembly of all the microcontroller circuits is inside a toy airplane, we made circuit size so small to fit in the body of airplane and work properly for this we made PCB (Printed Circuit Board) instead of working on Vero board. On Vero board circuit size increase and jumper wires create lot of difficulty in soldering and to maintain.

The circuits in airplane work on 6V. All stages circuits are separate, but connected to each other by connecting wires. The sensor which is attached with servo on front wheel is fully covered with aluminium tube to protect it from signals coming on its sides.

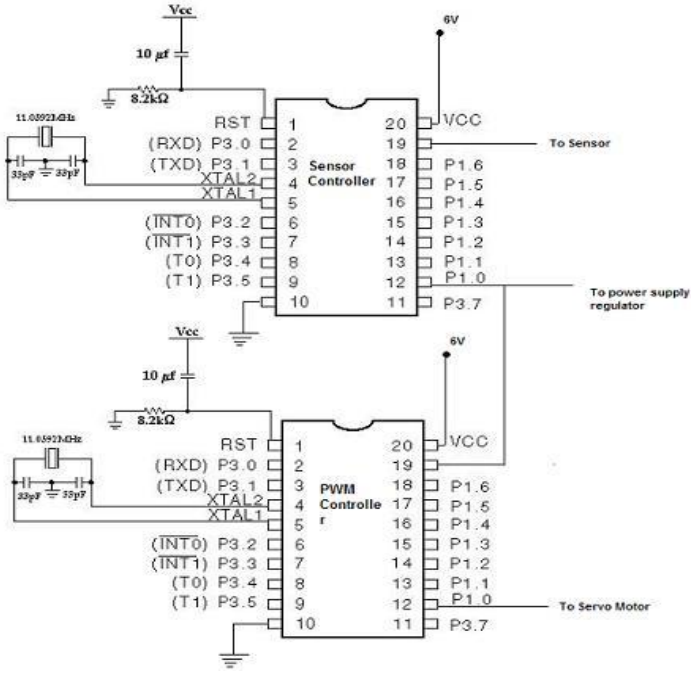

Figure 9. Inter controller communication

Figure 9 shows electronics connections among microcontrollers and figure 10 shows the practical implementation of the electronics circuit in an airplane.

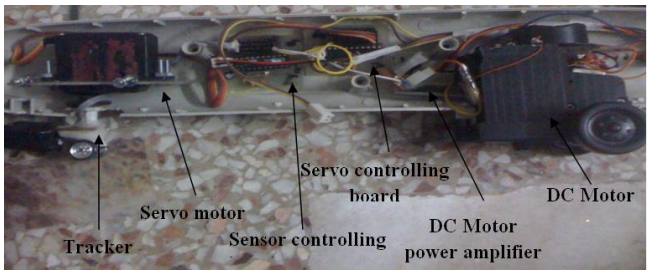

Figure 10. Assembly of components inside plane

IV. CONCEPTUAL WORKING

The working of this system is simple, the beacon is installed in way of the airplane between runway and subways, airplane then follows the path generated by the beacons, the demonstration of the system is given in this picture in with two airplane accessing the beacon, the sensor of the airplane sensing the beacon where as the transmitter of the airplane as also communication with the receiver of the beacon. The whole arrangement of the system is shown in figure 11.

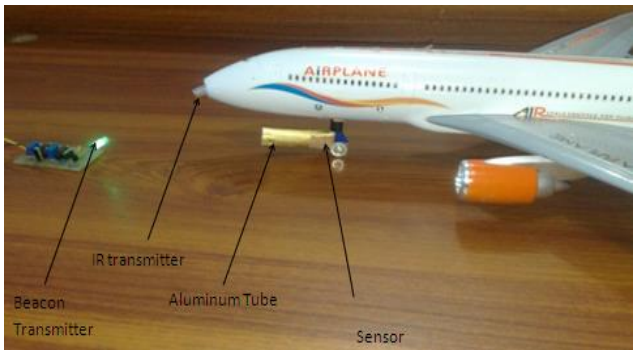

Figure 11. Model of the system

V. DISCUSSION

Taxi scheduling is always considered to be secondary to arrival and departure scheduling, since it is easier to guarantee safety [7,8,11,12] on the ground than in the air. The Ground Controller should make sure that conflicts are avoided. The need of such a system is proposed because of few issues like non availability of secure taxiway for the aircrafts, post landing accident avoidance system are non-existent, no catering of human error and delays, poor scheduling of international flights [4], no post landing high tech guidance system. The taxi schedule that is presented to the controller must be conflict free. Conflict scan occur when aircraft are too close together and there is a possibility of a collision between (two) aircraft.

VI. CONCLUSIONS

This proposed system of automatic post landing of aircraft helps pilot after landing the aircraft, it provides an auto path for the taxiing and docking [5] of the plane towards the docking area. System will detect the plane when it enters into the runway, it will generate the path which is to be followed by plane. Presently, most of our airlines/civil aviation authority are running with considerable losses. Our proposed system can help the air staff to handle more air traffic simultaneously; this helps our country to generate more revenue through civil aviation.

REFERENCES

[1] Babak Ghalebsaz-Jeddi , George L. Donohue, John F. Shortle; A Statistical Analysis of the Aircraft Landing Process; Journal of Industrial and Systems Engineering Vol. 3, No. 3, pp 152-169 Fall 2009

[2] Shinya Umeno and Nancy Lynch: Proving Safety Properties of an Aircraft Landing Protocol Using I/O Automata and the PVS Theorem; ProverJ. Misra, T. Nipkow, and E. Sekerinski (Eds.): FM 2006, LNCS 4085, pp. 64–80, 2006.

[3] AIR FORCE INSTRUCTION 10-1001: CIVIL AIRCRAFT LANDING PERMITS; Supersedes AFR 55-20, Section A,B,C and D, 10 April 1987

[4] Aron, I., Lungu, R., Cismaru, C.: Aerospace Navigation Systems, (in Romanian). Scrisul Romanesc, Craiova, (1989)

[5] Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System, Final report, John A. Volpe National Transportation Center, August 29, 2001.

[6] Aero Students: Landing Procedure of aeroplane /www.aerostudents.com/files/aircraftPerformance2/landing.pdf (accessed 17/12/2012).

[7] Proving Safety Properties of an Aircraft Landing Protocol Using I/O Automata and the PVS Theorem Prover: A Case Study, J. Misra, T. Nipkow, and E. Sekerinski (Eds.): FM 2006, LNCS 4085, pp. 64–80, 2006.

[8] SAFETY ADVISOR: Air Safety Foundation (AOPA): http://www.aopa.org/asf/publications/sa08.pdf (accessed 16/01/2013).

[9] Infrared-optical multisensor for autonomous landing guidance... http://proceedings.spiedigitallibrary.org/article.aspx?articleid=998253 (accessed 20/01/2013).

[10] The Final Approach and Landing Segment www.ifly.com/blog/approach-and-landing (accessed 24/01/2013).

[11] THE AIRPORTS (ECONOMIC REGULATION) ACT : http://www.moj.gov.jm/sites/default/files/laws/The%20Airports%20(Economic%20Regulation)%20Act(back-up).pdf (accessed 24/01/2013).

[12] ATSB TRANSPORT SAFETY REPORT: Aviation Occurrence Investigation; Hard landing Darwin Airport, Northern Territory (accessed 24/02/2013).

[13] Statistical Summary of Commercial Jet Airplane Accidents: www.boeing.com/news/techissues/pdf/statsum.pdf (accessed 24/02/2013).