CHAPTER 1

INTRODUCTION

1.1 Background of Study

"Cansat" or also known as AeroUTP is a nano – scale satellite models invention integrated within a soft drink can be launch up using balloon to perform a fully autonomous mission [1]. "Cansat" deliver missions for performing several scientific experiments such as altitude control using parachutes and GPS measurement for satellite tracking system.

"Cansat" is designed to be a lightweight satellite with harmonious data acquisition system intergrades with certain important parts which are data handling unit, communication subsystems, structural and altitude control subsystem will produce excellent autonomous flight navigation system.

The "Cansat" must stop its movement over a given target, by means of aerodynamic control during the descent phase or terrestrial navigation once landed. It will be taken into account not only the accuracy, but also complexity and originality of both control and navigation systems.

The mission requires the structural integrity of the satellite to be maintained from liftoff and landing. This will be accomplished by deployment of parachute able to withstand at least 20Gs of shock.

1.2 Problem Statement

Global Positioning System or also known as GPS is very crucial subsystem for implementing autonomous flight navigation systems. The line of sight in term of longitude and latitude coordinates will be lost if GPS not work properly. Compact & Effective GPS Board with perfect antenna need to be determined for track up as much satellites at once with one-second updates for any changes of positioning of that satellites.

If GPS can detect only 2 satellites at once, 2D image will be displayed in imaging part subsystem. For the good visualizations, GPS board need to identify at least 4 satellites which will produced 3D image (2).

The design of the payload's parachute is critical and requires significant attention. The parachute must be capable of deploying and slowing the payload to a safe landing speed to ensure the payload is recoverable. Calculations and tests will have to be done to design the correct parachute size.

Parachutes need to design and continuously testing of a fail-safe parachute deployment mechanism because parachute cannot be deployed using any kind of pyrotechnics. For the simulation part, parachute will be attached with same weight of real payload so that any errors like shocking vibration acceleration can be analyzed.

Specific mechanism for controlling the motor using relay should be applied in order to bring back the payload to certain point targeted without human interaction. Thus robot technology known as "Mini Robot" had been invented with the function to bring payload using wheels to target point based on differences distance level value of positions (latitude and longitude) calculated by GPS.

1.3 Objective and Scope of Study

1) Build autonomous navigation system for satellite
2) Come back to a certain point autonomously without human interaction
3) Payload can be reusable after post flight testing

1.4 Relevancy of the project

"Cansat" development involved complex engineering projects starting with the conceptual ideas & design followed by integration of circuits and last but not least implements testing to verify the actual operations of the system .

"Cansat" project is a design-build fly back prototype architecture that gives opportunity to experience directly about basic life-cycle of an aerospace system. The missions and requirement are designed to reflect about actual operations of power subsystem and navigation subsystem with autonomous operations.

CHAPTER 2

LITERATURE REVIEW

Autonomous Flight Navigation System can be clarified where the integration of system in "Cansat" itself function perfectly without any human interactions [1]. "Cansat" with certain steering mechanism which is using parachute will release from balloon after reaching at apogee and landed safely to the ground station [2][3]. Then payload which is facilitating with wheels will travel from drop zone to launching point autonomously [4].

Navigation can be separately into 4 phases which are launching parts, parachute release, gliding towards ground stations and travelling part from drop zone to launching point. Effectiveness or successful of the mission depend on how the integration of the satellite system because navigation guidance control seems to be the major constraints to provide flight navigation system autonomously [5][6]. All structure and components shall fit inside soda can and most importantly total mass of "Cansat" not too heavy which may lead of overweight while launching to the sky [1][3].

Other than that, Autonomous Flight Navigation System actually utilizes Global Positioning System (GPS) technology for ensuring that "Cansat" always keep on track throughout the missions. Some test will be conducted on GPS Receiver alone to determine accuracy of data collected. Time duration of the receiver to lock the gain signal also will be testifying throughout the test as consequences if the signal is temporarily lost at the sky [7].

GPS also can be to determined exact distance between drop points to launching zone. Mini robot had been invented with the function to bring payload using wheels to target point based on differences distance level value of positions (latitude and longitude) calculated by GPS.

Structural designation should be as consideration to withstand the drop and impact upon landing. In addition, structure of the “Cansat” also can provide additional protection to the GPS module without hindering its functionality [6].

2.1 GPS Receiver

The Global Positioning System, as it name implies is a system whereby it is used to track a position on Earth at a given time. The system uses a constellation of 24 medium Earth orbit satellites at 20,200 km above sea level that transmits precise microwave signals that enables a GPS receiver on Earth to be able to receive information on location, speed and direction [8].

Parallax GPS Receiver module been chosen to integrate into the Payload block diagram based on the most cost-effective and interoperability functions in collect data needed [9]. It is fully integrated, low cost complete with on board patch antenna.

Parallax GPS Receiver use National Marine Electronics Association (NMEA) – 0183 strings or specific user- requested data via the serial command interface tracking up to 12 satellites and Wide Area Augmentation System / European Geostationary Navigation Overlay Service (WAAS/EGNOS) standard output for tracking the satellites so that exact position of the “Cansat” can be determined [8][9].

Figure 1: Parallax GPS Receiver Module

The Parallax GPS receiver module in Figure 1 above provides current times, date, latitude, longitude, speed and travel direction / heading among other data. GPS Receiver module is controlled by the host via an easy-to-use, Time to Live (TTL) level, asynchronous serial communication serial interface. The Single Input Output (SIO) pin transfers commands sent to the module and data received from module. All communication is at 4800 bps, 8 data bits, no parity, and 1 stop bit and non-inverted [9].

Upon power up of the GPS receiver module in a new location, the module may take up to 5 minutes or more to acquire a fix on the necessary minimum number of four satellites. During this time, single red LED (light-emitting diode) on module will blink. When enough satellites are acquired for module function properly, red LED will remain solid red [10].

2.1.1 GPS Operations

Global Positioning System or also known as GPS can be used for determine the accurate position of the satellite throughout the flight operations. Parallax GPS Receiver with model 28146 track location using the trigonometry to find the relative position of the satellite.

If GPS can detect only 2 satellites at once, 2D image will be displayed on LCD display. Thus GPS module need to lock at least 4 satellites for giving good visualizations. Parallax GPS receiver using serial data interfaces for transmitting the data. It is using Serial Input Output (SIO) pin or the "/RAW" pin out that allows users to use raw GPS data directly and can be left unconnected [7].

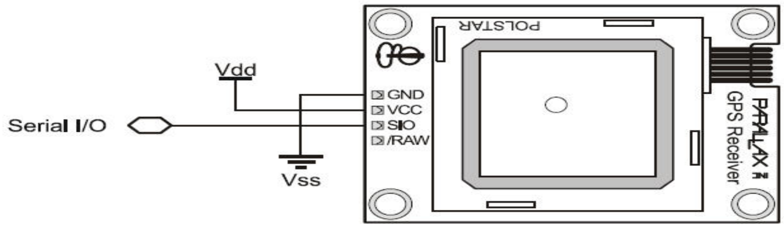


Figure 2: Parallax GPS Receiver Module pin out

GPS will be interconnecting with serial LCD with Rx pin for displaying the output [10][12]. Serial LCD is representing the ground station functions as controlling and detects the position of the satellite and keeps it on track.

Serial LCD with Rx pin is the best solution and cost effective integrated with PIC microcontroller for displaying characters on LCD screen. Most importantly, only three wires needed to interface to the LCD which are +5V, GND and Rx pin out for data signal to be matched with 3 pin out of GPS receiver [12].

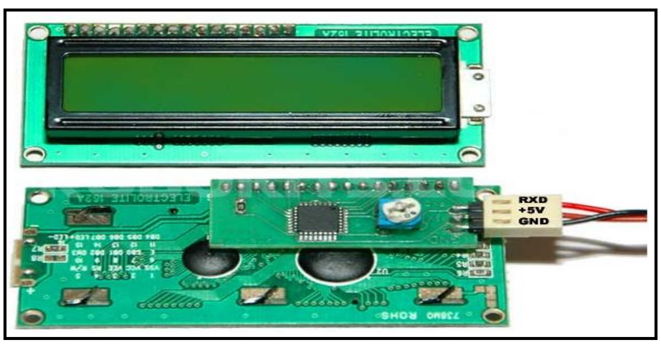


Figure 3: Serial LCD hardware

Figure 4: Serial LCD output

As soon as the initial self-test is complete, Parallax GPS receiver begins the process of satellite acquisition and tracking automatically. After a position fix has been determined, information will be transmitted over the serial LCD display [9].

After the acquisition process is complete, Parallax GPS receiver sends navigation information consists of [9][11]:

Table 1: Parallax GPS Receiver Navigation Information

Information	Returns the model of the GPS receiver
Validity	Returns a 0 if the reading of a signal is invalid and a 1 if the reading of the signal is valid
Satellites	Returns the number of satellites that the GPS receiver is currently receiving information from
Time	Returns 3 variables: hours, minutes, and seconds
Date	Returns 3 variables: month, day, year
Latitude	Returns 3 variables: degrees, minutes, and seconds
Longitude	Returns 3 variables: degrees, minutes, and seconds
Speed / Velocity	Returns speed / velocity in m/s

2.1.2 GPS for determine distance

Besides using GPS for tracking location, GPS also play roles to determine exact distance between 2 points starting from the launching point to landed point as information of latitudes and longitudes give exact coordinates for the satellite.

The initial coordinates (launching point) will be marked as references. Distance between two places can be determined by using “Haversine” formula so that payload can move using wheels to fulfill the mission for reaching the launching point once landed to the earth [13].

“Haversine’ formula is equations derive specifically for navigation giving accurate distances between two points on a sphere great circle based on current latitude and longitude coordinates [13].

Φ 1 and φ2 in equation below represents the position captured by GPS. Φ1 is the initial positions at launching point and will be point of references for calculating exact distance at post flight operation soon. φ2 is the positions to be captured by GPS once Cansat is safe landing to the earth.

$$\operatorname{haversin}\left(\frac{d}{R}\right) = \operatorname{haversin}(\varphi_1 - \varphi_2) + \cos(\varphi_1)\cos(\varphi_2)\operatorname{haversin}(\Delta\lambda). \quad \text{………..2.1}$$

where

- haversin is the haversine function, haversin(θ) = $\sin^2(\theta/2)$
- d is the distance between the two points (along a great circle of the sphere; see spherical distance),
- R is the radius of the sphere,= 6367.45 km
- φ_1 is the latitude of point 1,
- φ_2 is the latitude of point 2, and
- Δλ is the longitude separation,

Distance between Φ 1 and φ2 can be simplified by using arcsine (inverse sine) formula. Distance calculated using formula below represents in meter.

$$d = R \operatorname{haversin}^{-1}(h) = 2R \arcsin\left(\sqrt{h}\right) . \qquad \text{..............................2.2}$$

where

- *h* is haversin(*d*/*R*)

Initial position and last position for determining latitude and longitude will be stored in PIC memory [14][15]. Certain mechanism must be used for enable the PIC that acts as brain to store positions captured. Thus, mini robot will move from point 2 to point 1 and will stop moving once reached at that reference point.

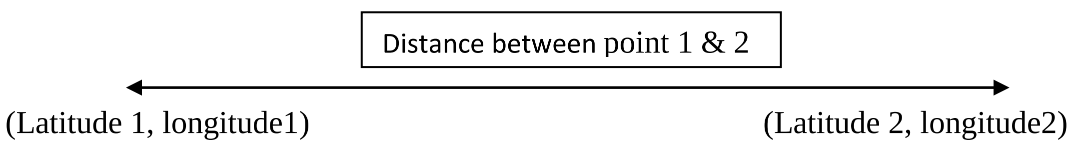


Figure 5: Latitude & Longitude Position for Navigation

2.2 Parachute

Other than that, recovery system composed of parachute designation must give more attention which acquires a lot of testing to ensure that flight navigation system work autonomously [16]. Most of the failure of “Cansat” development begins from parachute at time all the subsystems ready to be operate. Parachute would be deployed in mission that:

1) Able to withstand 20Gs of shock so that data from payload can be extracted for scientific research.
2) Payload can be reusable after post flight testing performed

Numerical simulation of the flow around hexagon parachute has been studied as an example of numerical fluid dynamics [17]. This designed had been choose because it is simple to make and can flies forward without using any electrical power.

2.2.1 Parachute Designation

Parachute designed by own to ensure that payload will bring back payload safely to the ground stations. Payload consists of raw data of navigation system and experiments to be extract at post flight analysis later on [18]. Parachute designation will bring the payload fly to the ground station safely by pulling & loosing the control line of the parachute considering effect of aerodynamics disturbance, relation between control line and aerodynamic characteristic of parachute, multi-body modeling of the motion of the payload and parachute and obey the control law.

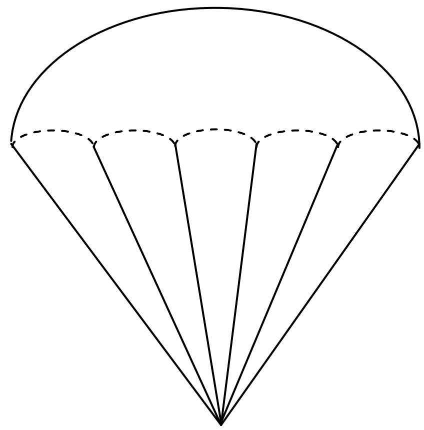


Figure 6: Parachute Structure

The mission requires structural integrity of the satellite to be maintained from liftoff and landing. This will be accomplished by deployment of parachute bring safe payload, able to withstand at least 20Gs of shock.

Several criteria should be fulfilled for designation of the parachute which is:

1) Descent rate

   The parachute should provide sufficient drag coefficient to reduce the descent velocity to an acceptably low value to meet the required descent time from apogee (150 meter) to the ground

2) Strength

   The parachute must be strong enough to withstand the opening force without damage. Strength of parachute can be determined by calculating resistance force (drag coefficient) which opposes the motion of payload.

3) Stability

   The parachute must be stable enough to keep the oscillation of "Cansat" to glide back to target point and bring back the payload safely. For that reason, surface area of the hexagon parachute must be larger than minimum parachute area for safe descent rate.

4) Suspension line

    Nylon string used to make the suspension because it is strong enough to withstand the tension of the payload while descending

5) Material used for parachute

    Light fabric must be taken as consideration for designing the parachute. Other than that, that material should also capable to hold the resistance of air, drag force act on falling body of parachute to slow down the motion of payload so that mission for bringing back payload safely to the earth will be accomplished.

Hexagonal Parachute with 6 suspension lines is the best design for fulfill the criteria above. 2 forces act on parachute which are drag and weight forces. Parachute will be in equilibrium or no velocity occurs so that drag forces will be same as weight forces [17].

CHAPTER 3

METHADOLOGY / PROJECT WORK

3.1 Research Methodology

Cansat development involved two main phases which are pre-launch operations and flight / launching operation [3]. Each operations needs to be well operated to ensure the success mission completed without any error recorded.

3.1.1 Research Methodology for Pre-Launch Operations

"Cansat" development acquires sophisticated engineering integrated with designing, testing, troubleshooting and most importantly no error records during the real simulation conducted. In designing circuit diagram, a lot of datasheet such as relay, GPS, Serial LCD with Rx pin and other datasheet should be referred to enhance understanding and get clearer view about whole of the navigation operation [10][12].

After sketch the circuit on the paper, the circuit is then built on a breadboard to apply the theory that had been learnt before. If the output is not as expected, it will debug until it works. Most common problems are grounding issues and current drop while troubleshoot performed.

PIC 16F877 microcontroller is chosen due to friendly user peripherals. It is easier to decide any devices to be attached at microcontroller without worrying that there is not enough pin to be inserted for further experiments since it has 40 pin. Other than that, less multifunction in each pin so that easier to user use that ports.

All the parts of “Cansat” system can be integrated using C code by making input and output controlled using PIC16F877 microcontroller [14][15]. After software and hardware theory done, Printed Circuit Board (PCB) created taken from schematic design for completed the design.

Each subsystem involving data handling units, power units and navigation subsystem will undergo rigorous testing during the fabrication process to ensure the reliability. After building and testing, re-evaluation of the objectives will be held in order to ensure that it accomplish its mission

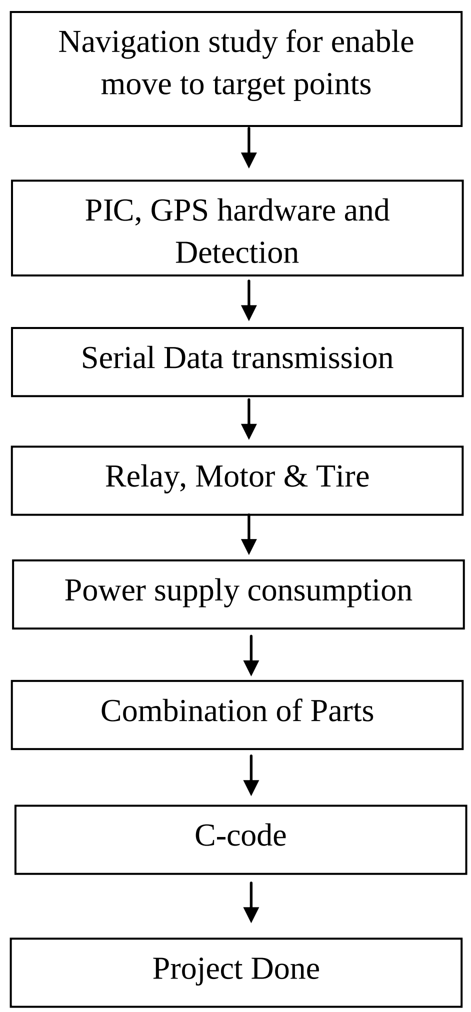


Figure 7: Circuit development for navigation system

3.1.2 Research Methodology for Launch Operations

Flow diagram in Figure 8 below described about the operation of Autonomous Flight Navigation system that will commence during the actual simulation. “Cansat” development can be break down into four main parts which are launching operations, parachute release, gliding towards ground station and travelling part from drop zone to launch target.

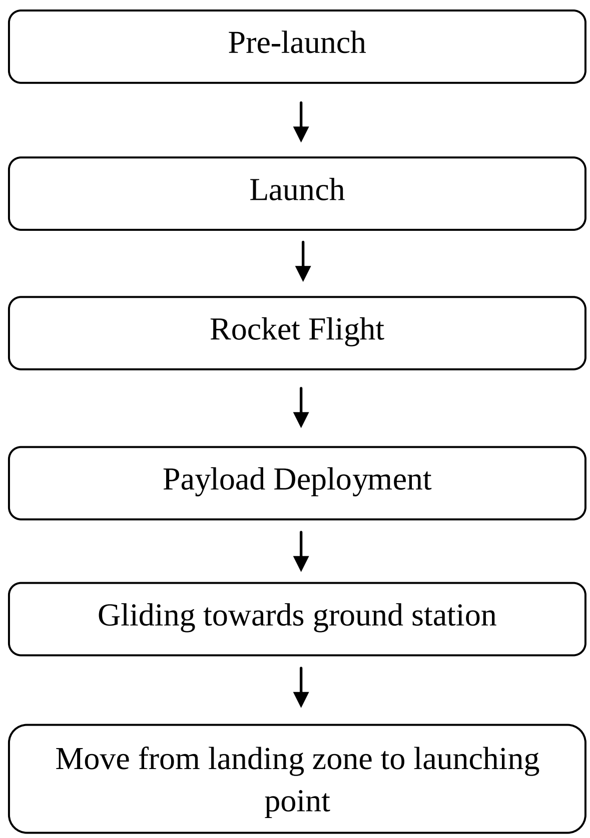


Figure 8: “Cansat” Development

During launching / flight operation, GPS starts to do initial self-test for reboot and waiting for satellite acquisition and tracking automatically. This process acquires around 38 seconds to lock at least 4 satellites. Received data of information from GPS will be displayed via serial LCD display. Serial LCD display represents the ground station part for tracking location of the satellite. From point onward, serial LCD display will receive data transmitted from “Cansat”.

During flight, “Cansat” payload instrumentations continually take the measurement including pressure, longitude, and latitude and frequently transmit data to the ground stations successfully deploy the parachute after jettison from the rocket allowing around 90 seconds to descent.

After payload safely landed down to earth, “Cansat” operations will stop for a while to ensure that parachute fully falls to the earth. Then, payload will move towards the launching point via wheels. Payload will continuously moved based on differences distances computed by GPS data. “Cansat” system will stop operation instantaneously after reaching at targeted point.

Post flight operation consists of raw data that had been collected during the simulation. All raw data need to be extracted to give certain information especially about the pressure at certain level on air.

3.2 Key Milestones of "Cansat" Development

"Cansat" research and development (R&D) actually can be categorized into two phases involved 1st semester starts from January 2009 till June 2009 and 2nd semester of final year starts from July 2009 till December 2009.

1st Semester

- Proposal for "Cansat" Development
- Theoretical Study
- Design of model
- Choosing suitable component for hardware construction
- Software development and engineering study using MPLAB, PCC-Lite compiler and Eagle [14][15].

2nd Semester

- Purchase hardware such as Parallax GPS Receiver, Serial LCD Display, GearBox [9][12]
- Fabrication Process
- Experimental Procedures
- Test Readiness Review
- Simulation Analysis
- Final Design Review

3.3 Gantt Chart

The schedule for completing project within semester one & semester two project is shown below in the form of a Gantt chart. The entire task has been prepared as guideline for complete whole operation of “Cansat” research and development (R&D). All the tasks need to be meeting this timetable and system will be work at most end of week 13 Semester 2 Final Year Project Milestone.

Milestone for Semester One Final Year Project

No	Details	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Proposal of Autonomous Flight Navigation System														
2	Identify & allocation of the task														
3	Identify suitable devices to be use in Cansat navigation														
4	Preliminary Report Submission														
5	Work on architecture structure														
6	Learn IDE, Hi-Tech & Java programming for Cansat development														
7	Trip to ATSB for understand the Cansat operation														
8	Data Transfer algorithm in payload system														
9	Submission of progress report														
10	Learn on how to calibrate servo motor														
11	Designation of own parachute for comparison with ready made parachute														
12	Draft Report Submission														
13	Interim report Submission														

Milestone for Semester 2 Final Year Project

No	Details	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Engineering Review Studies	■													
2	Purchase Parallax GPS Receiver	■	■												
3	Parachute Design & Testing for recovery system		■	■											
4	Software Development using MPLAB & PICC-Lite				■	■	■								
5	Submit Progress Report						■	■							
6	Purchase Serial LCD for output display							■	■						
7	Fabrication design & process							■	■	■	■				
8	Experimental Procedures								■	■	■	■	■		
9	Test Readiness Review										■	■			
10	Simulation Analysis												■	■	
11	Technical & Dissertation Report													■	■

3.4 Components in "Cansat" Navigation System

Cansat development acquires certain components and tools in order to fulfill the mission. Components can be divided into 3 sub sections which are GPS tracking/navigation for determine the location., recovery system for bringing payload safely to the ground and mini robot development to bring payload to launching point before ending the operations.

All the tools and electronics components integrated will give perfect operations controlled by PIC 16F877 [14].

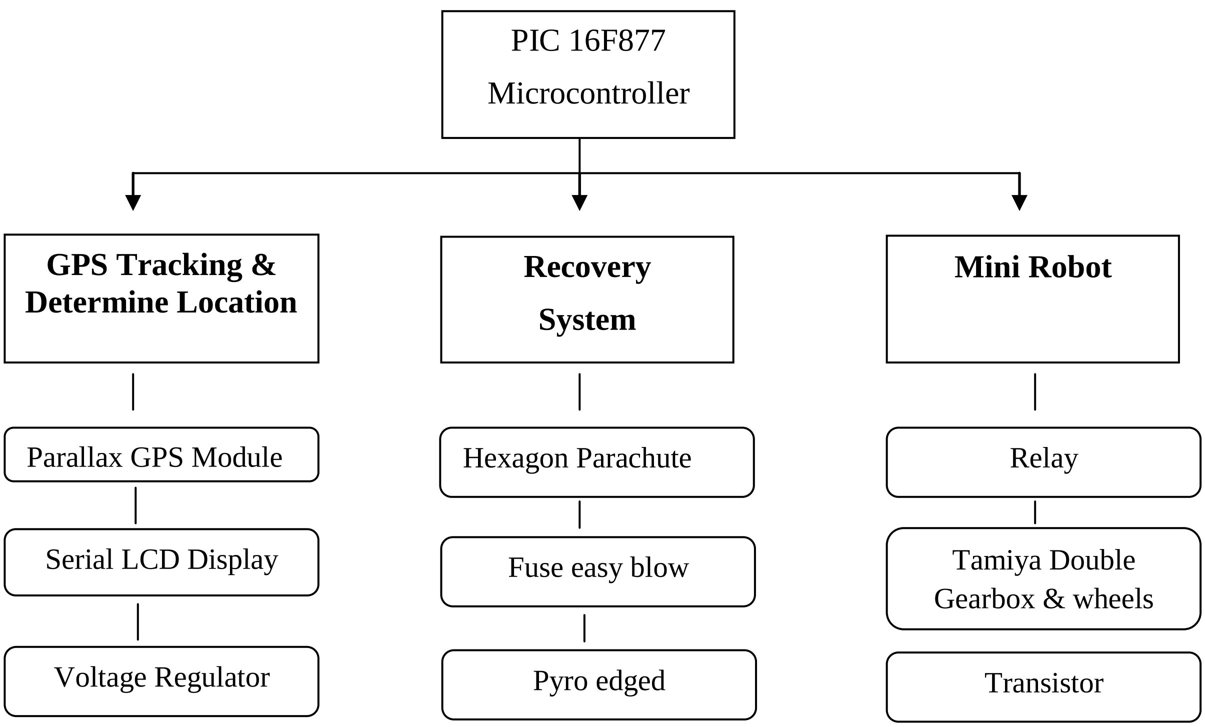


Figure 9: Payload Block Diagram in "Cansat"

3.5 Navigation System in "Cansat"

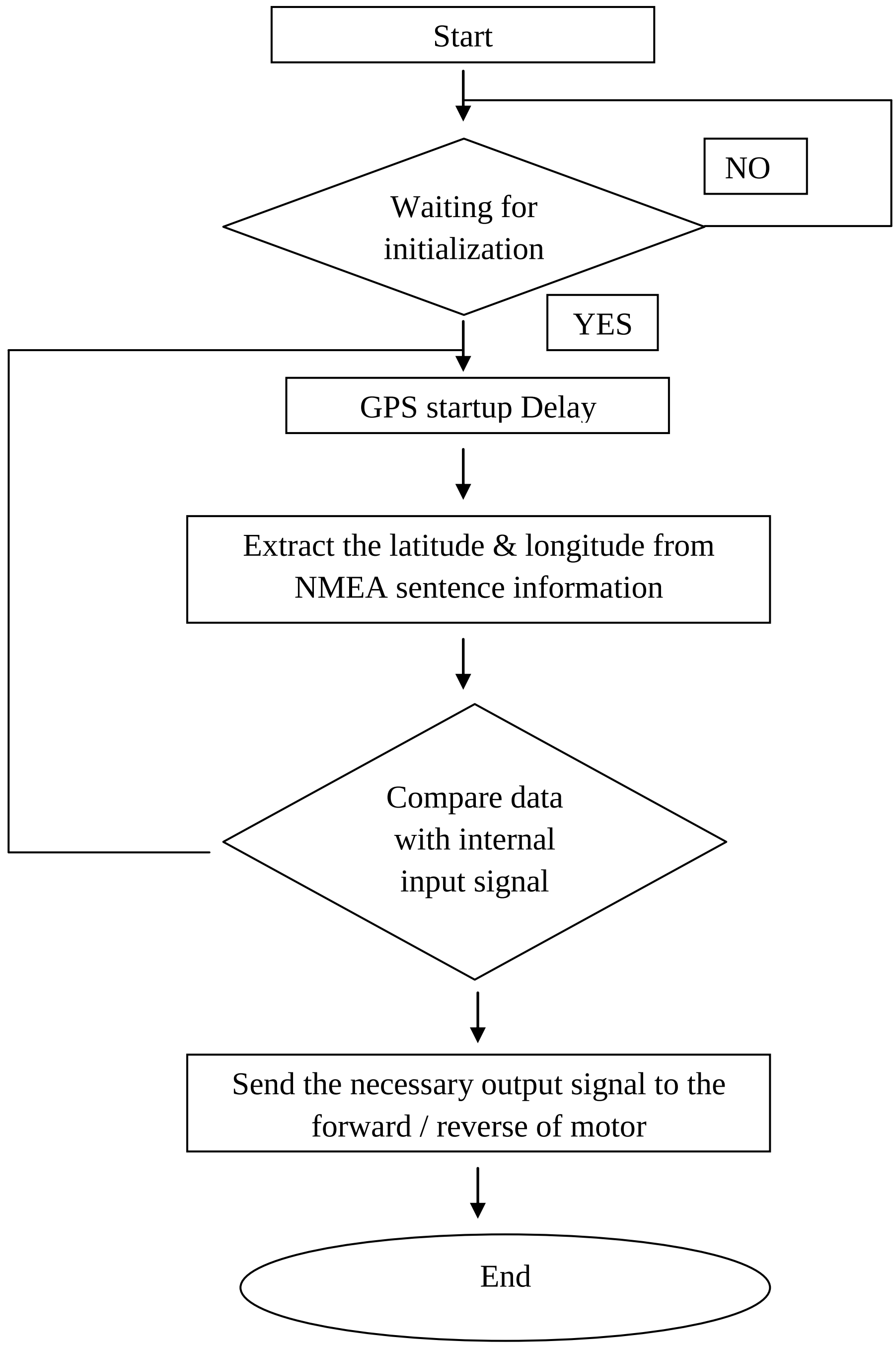


Figure 10: GPS Navigation Module (Parallax GPS Receiver)

3.5.1 Software Block Diagram in Navigation System (GPS & Pressure Sensor)

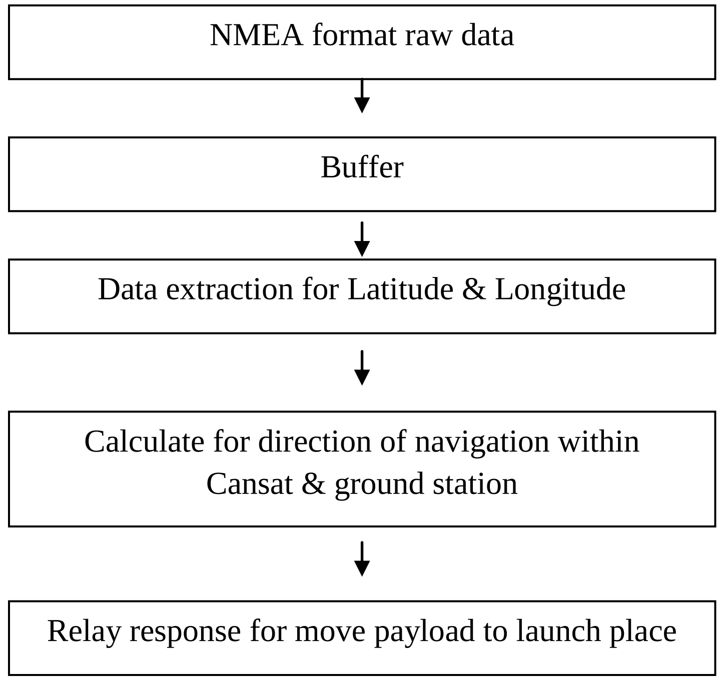


Figure 11: GPS receiver extraction data for navigation system

3.6 Items Needed for "Cansat" Development

Table below shows the items needed for cansat development with the cost. Purchase of equipment will be recorded so that actual value of cost of whole operation can be calculated.

Table 2: Items for "Cansat" development

No	Items	Price (RM)
1	GPS Parallax Receiver	645
2	Serial LCD Display	200
3	Relay	12
4	Tamiya Double Gearbox	42
5	Parachute	20
6	PIC 16F877A	24
7	Power supply	10
	Others	60
	Total price	1013

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Data Gathering and Analysis

"Cansat" with fly- back design use balloon for lift up the payload to the sky. The balloon is estimated to remain aloft for a period of 30 minutes so that it will sufficient enough to reach altitude of 500 feet.

Payload of satellite will be equipped with GPS receiver on top lid of it to avoid any disturbances for detect the satellites in orbits [5]. At least 3 satellites needed to be detected for displaying the actual latitude, longitude and updated time being. So that exact position can be determined. Recovery system via parachute will be released from a balloon at 150 meters of altitude and glide towards earth.

Differences between 2 points store by microcontroller determined exact distance from dropping zone to launching point. Control mechanism system using mini robots move towards launching point. Operation will be terminated automatically after payload reach at launching point.

Thus, interoperability and capability of each subsystem function perfectly give succession of the mission required without any human interventions.

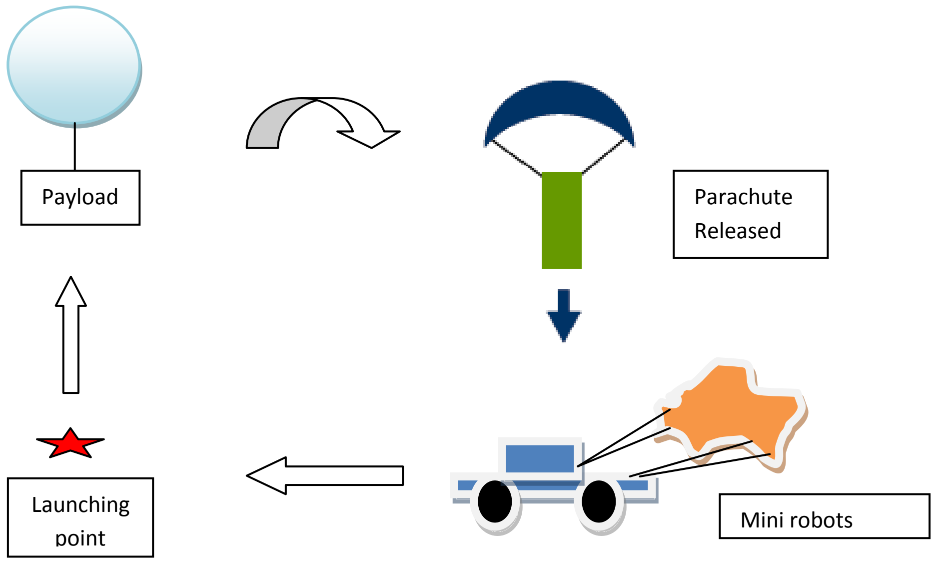


Figure 12:"Cansat" Operation

4.1.1 GPS for Keeping Track on "Cansat"

Parallax GPS Receiver with model 28146 becomes the backbone of the payload. Without GPS system, the position of "Cansat" could not be determined if the Line Of Sight (LOS) lost.

GPS output data represent in National Marine Electronics Association (NMEA) standard format delivers information in table below:

Table 3: NMEA-0183 string output messages

NMEA Output	Description
GPGGA	Global positioning system fixed data
GPGLL	Geographic position latitude/longitude
GPGSA	GNSS DOP and active satelites
GPGSV	GNSS satelites in view
GPRMC	Recommend minimum specific GNSS data

Low power consumption makes it is compatible with the payload system. Parallax GPS receiver should be put on "open sky" so that no disturbance for lock the satellites in acquisition process. Sometimes signal can be lost due to abnormal conditions. Self initial-test will be performed where all the previous data will be compared with updates information.

Default communication parameters for NMEA output are 4800 baud, 8 data bits, stop nit and no parity. Below are some of examples of NMEA-0183 output messages displayed on hyper terminal during the tracking process [8][9].

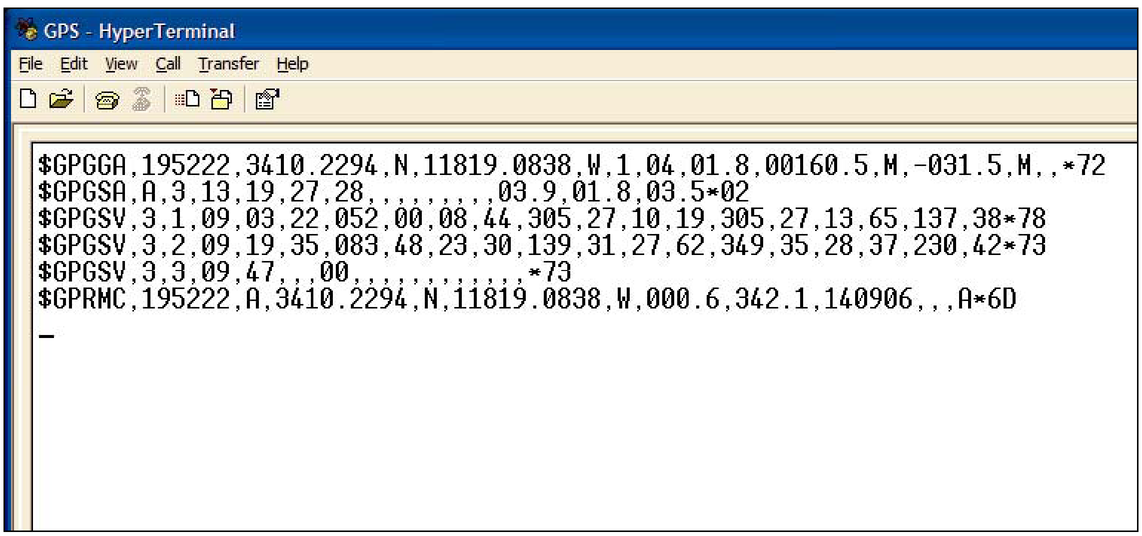


Figure 13: Hyper terminal Output Messages

For simulation purposes, serial LCD been used where it can be easily controlled by a microcontroller (PIC16F877A). LCD display is 2 lines by 16 characters and provides basic text so that the output of GPS can be displayed

Figure 14: Serial LCD Display with Rx pin output display

4.1.2 GPS for Calculate Distance between Two Latitude / Longitude Points

Parallax GPS receiver can be used as tools to determine the distance between 2 points accurately based on launching zone and drop zone. The distance between two references points can be calculated using GPS coordinates. GPS receiver report the location of both location in decimal degrees, minutes and seconds

Two latitude / longitude points can be determined by using Haversine Formula [13]. “Haversine” formula states that shortest distance over the earth’s surface between 2 points using the formula:

R = earth’s radius (mean radius = 6,371km) …………………………. Eq 4.1

$\Delta lat = lat_2 - lat_1$ …................................. Eq 4.2

$\Delta long = long_2 - long_1$ …………………………. Eq 4.3

Substitute Equation 4.2. and 4.3 into equation a below

$a = \sin^2(\Delta lat/2) + \cos(lat_1).\cos(lat_2).\sin^2(\Delta long/2)$ …………………………Eq 4.4

Substitute equation 4.4 into equation c

$c = 2.\mathrm{atan2}(\sqrt{a}, \sqrt{(1-a)})$ ………………………... Eq 4.5

Substitite c value for determine distance between 2 location

$d = R.c$ ………………………... Eq 4.6

For easiest way to calculate the positions, use the signed decimal degrees instead of decimal degrees, minutes and seconds.

Table 4: Signed Indication For Determine Location

Latitude	**Longitude**
North (+)	East (+)
South (-)	West (-)

For examples; suppose that launching point given by Latitude 1: 5’46’17.13” N and Longitude 1: 102’ 32’50.06” E while Latitude 2: 5’46’15.12” N and Longitude 2: 102’ 32’53.30” E .

Data for initialization position in GPS will be stored by PIC as references point for determine the exact distance once payload landing to earth. By having 2 distances for before launching and after landing period, PIC will be able to control and a=execute the motor to move to launching point based on formula above.

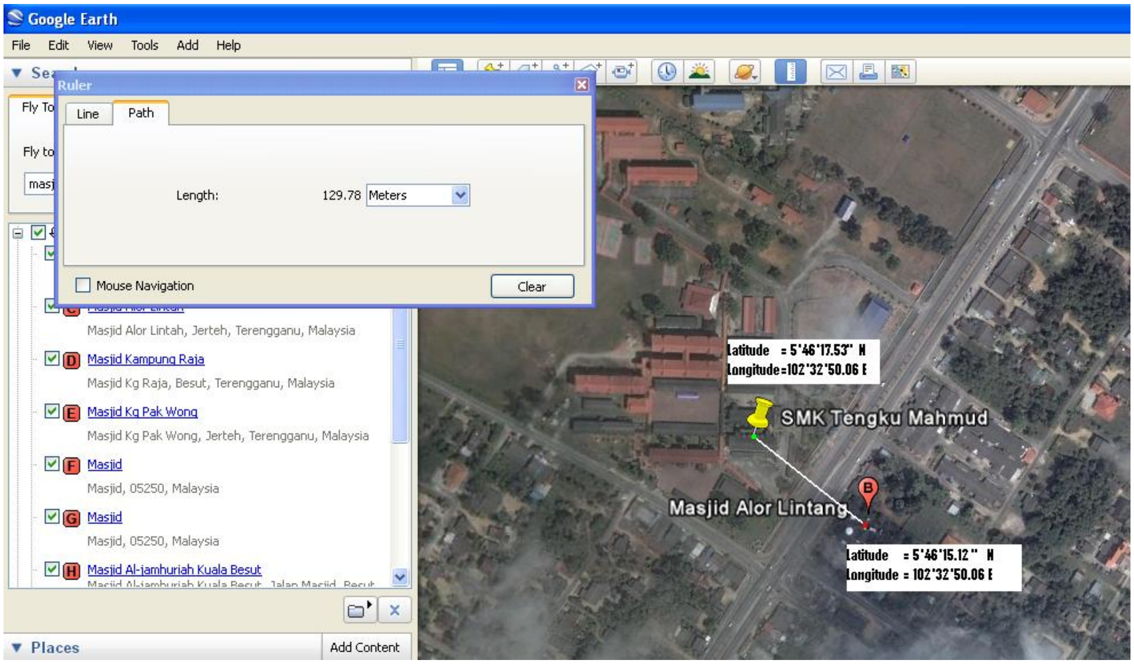


Figure 15: 2 points for location determination

“Cansat” will fly via balloon from latitude 1 and longitude 1 to the sky. After reaching 150 meters, parachute will deploy and landing to latitude 2 and longitude 2.By using 2 points references, PIC microcontroller will store data and calculate distance using “Harvesine” formula.

4.1.3 Mini robot

Mini robot with autonomously robot created bringing payload to the launching point for complete the mission required. This mini robot weighing around 500 grams can be deployed for the task powered using 6 dry cells for 9V power consumption.

It rides on track wheels controlling by PIC microcontroller and two geared motor that drive the wheels. Distance that must be traveled will be determined using GPS and payload will have lo located before it retrieved.

Designation of this mini robot slightly different compared to other invention where two wheels placed in front of the payload while at the backside will be supported using two inch of a nut as balancer. It is very important to have balancer at the operation where the parachute will glide back to certain point in mission bringing back the payload safely to the earth. Balancer will act to absorb the force that act on the payload so that damaged of payload can be minimized.

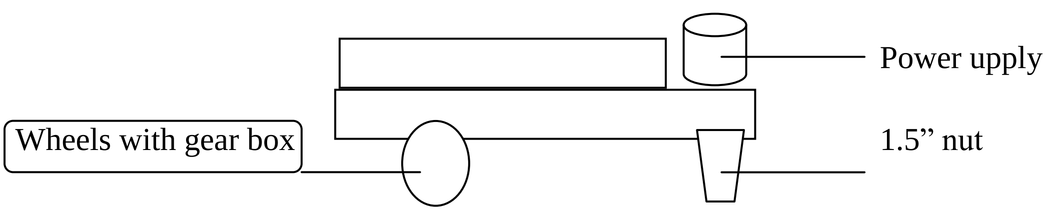


Figure18: Mini robots hardware

Attached to the gearbox are narrow wheel set. This wheel set is especially made to suit the DC motor gearbox shaft and it comes with a rubber that give a very good grip to any surface. Diameter of the tire is around 38 mm making around 1/5 of mini robot size while the width of the wheel is around 16mm.

A nut uses for balance two wheels despite supporting the front part of payload. The nuts located on the middle of backside where it can hold on weight of the robot and create distance between the body and ground.

Mini robot designation criteria:

1) Required a rugged, maneuverable off-road vehicle

2) Required robust operation in unstructured outdoor environment

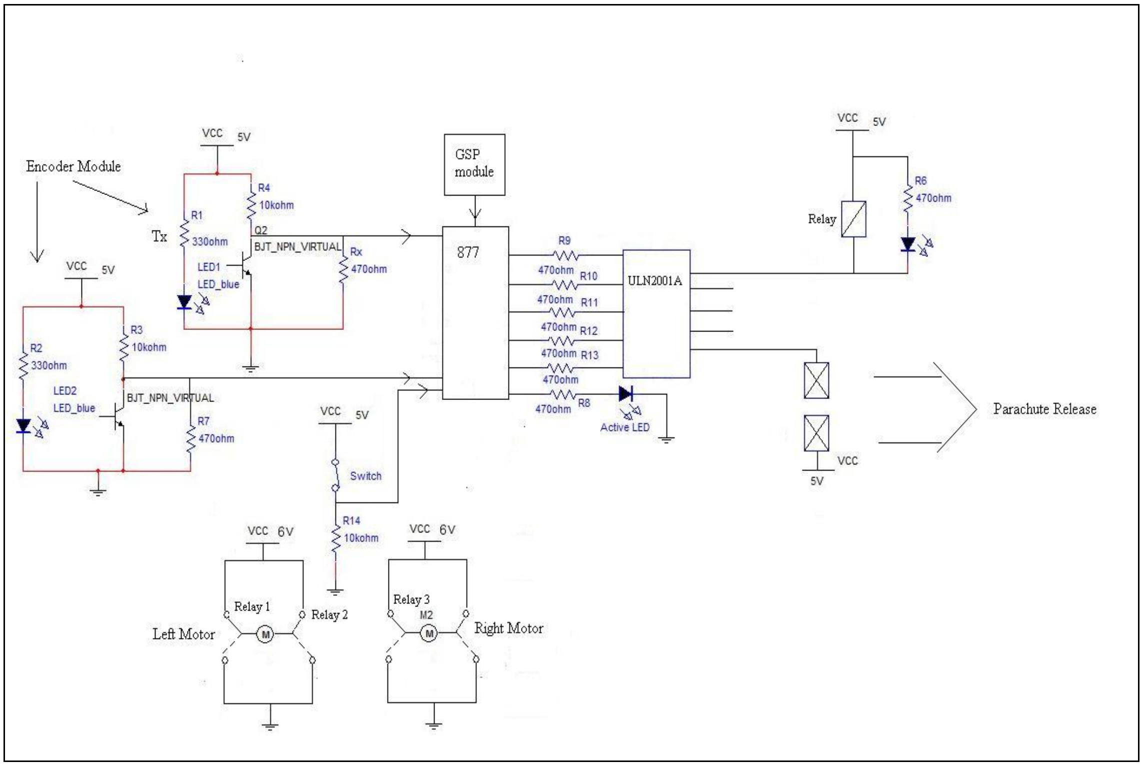


Figure 16: Moving mini robots circuit diagram

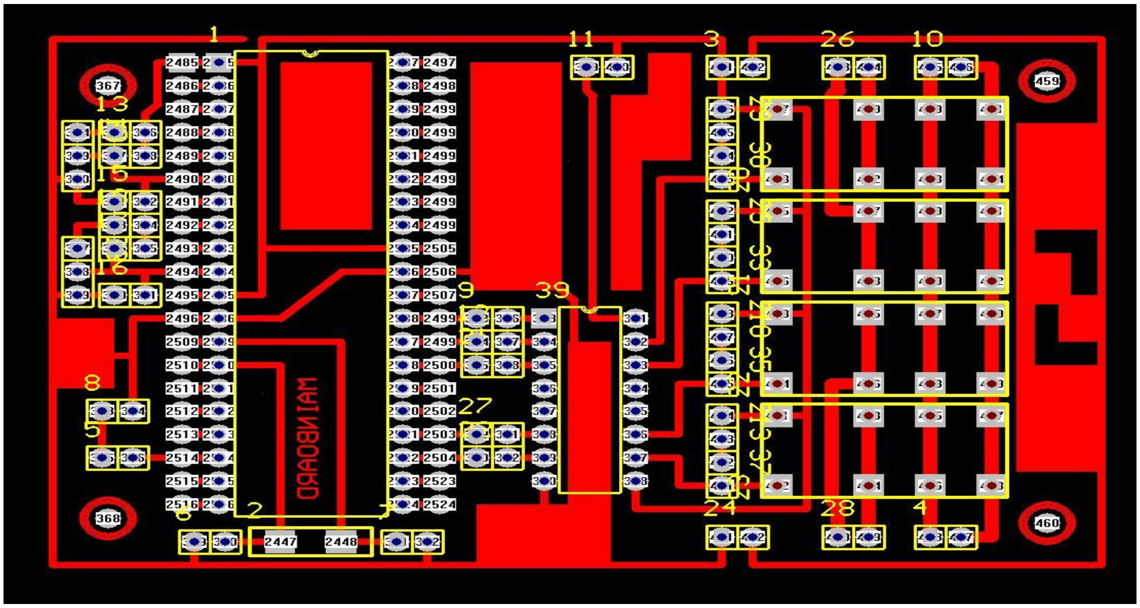


Figure 17: PCB schematic diagram for navigation system

4.2 Parachute Designation

There are two choices on recovery system selection; either using own design of parachute or buying standard parachute. At this moment, design with own recovery system give ultimate advantages which is reduced in weight, higher descent rate compared to standard parachute readymade in market nowadays. Standard parachute supplied by National Space Agency (ANGKASA) will be taken as point of reference and comparison for any modification of parachute designation.

Table 5: Advantages and disadvantages of own parachute design

	Standard Parachute	**Own Design**
Advantages	Fixed weight	Less weight consumed
	Fixed descent rate	More descent rate and can be modify based on testing
Disadvantages	Less time for construct & testing	More time on designing & testing
	Less risk for failure	High risk for failure

Polygonal geometry of hexagonal parachutes widely used for rocketeers for their recovery system to ensure that payload can bring back to earth safely. Some mathematical modeling applied to calculate the size of parachute needed to deliver requires minimum parachute area for a safe descent speed.

Parachutes must be designed using details for ensuring the stability and reliability of the recovery system throughout the operation or simulation conducted. Size of parachute is proportional to rate of descent.

Bigger size of parachute will give higher descent rate but weight also will be considered for maximizing the weight of whole satellites. Other than that, materials used for parachutes design must be light enough for giving more drag time.

In “Model Rocket Design and Construction”,2nd Edition, Tim Van Milligan provides useful formula for calculating the minimum parachute area needed for a safe descent speed, Ap for a given model rocket mass. The formula is given as:

$$A_P = \frac{2gm}{\rho C_d V^2}$$ ----- (Equation 4.7)

Where

g= the acceleration due to gravity, 9.81 m/s^2 at sea level

m = the mass of the “Cansat” (350 gram)

ρ = the density of air at sea level (1225 g/m^3)

C_d= the coefficient of drag of the parachute

V = the descent velocity of the rocket, 11 to 14 ft/s (3.35 m/s to 4.26 m/s) being

Considered a safe descent speed

Drag coefficient of parachute need to be determined for fulfill in Equation 1 formula above. Drag coefficient is force opposing weight. Higher drag coefficient indicates slower it falls. Other than that, shape of an object also gives great impact of the amount of drag. More polygon shapes such as hexagon polygon give more drag coefficient compared round parachute designation.[17]

Drag coefficient formula given by:

$$C_D = \frac{\text{Drag}}{q * s} \text{ or } \frac{\text{Weight of Parachute}}{q * s}$$ ----- (Equation 4.8)

Where

Weight of parachute = parachute mass (in lbs)

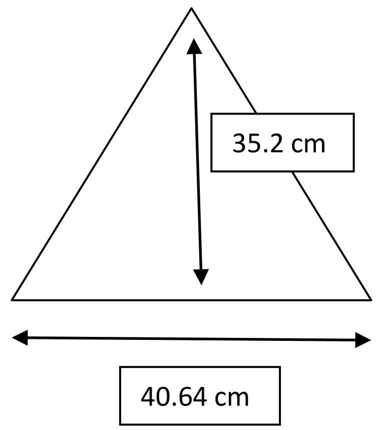
q = dynamic pressure = 0.5 pv*v

s = surface area

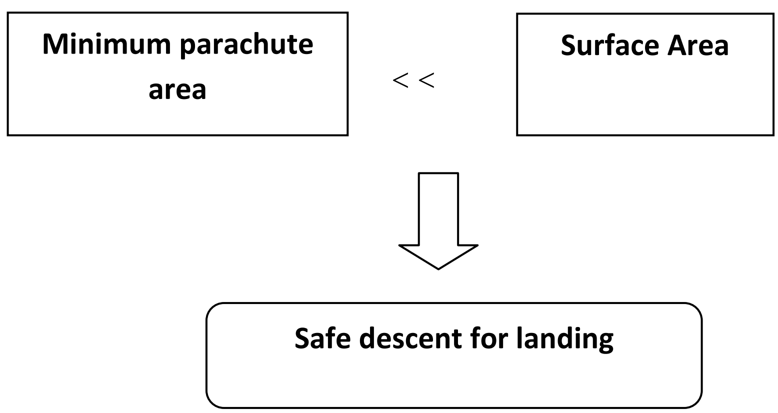
Surface area of hexagon from Equation 2 can be computed by using formula:

$$A_h = 6A_T$$ ----- (Equation 4.9)

where A_T is the area of the triangle and A_h is the area of the hexagon.



Safe descent for landing only applicable when minimum parachute area values (Equation 4.7) is smaller than surface area of hexagon parachute (Equation 4.9).



4.2 Experimentation / Modeling

“Cansat” Navigation system acquire integrated system that enable to do navigation throughout the simulation conducted and lastly bringing back payload in safe condition so that all the data can be extracted for further analysis. The higher of descent rate indicates the safer payload will be bringing back to the ground.

After successfully identifying the requirement to build up the model of parachute, simulation will be performed to check the way “Cansat” descends using selected parachute. Besides, this simulation will identify alternatives the way carrier releases “Cansat” without any errors / successfully deployed.

Simulation will involve soda can fulfilled with sands and parachutes. All the constraint like cross wind will be considered throughout the simulation conducted. Velocity of cross wind will be increased up to 70 km/h to ensure that parachute able to oppose the constraint and land at target point autonomously.

Basically 2 types of test will be conducted by using can fulfill with sand as the same weight of real payload system in “Cansat”. It is very important to simulate and testify reliability of parachute whether stable, unstable or collapse throughout the experiment conducted.

For testing the parachute designation, certain aspects will be observed such as:

1) Reliability
2) Shroud line functions as hook between parachute and payload; additional line will give extra strength especially face the wind tunnel.
3) Shape of parachute
4) Diameter effect by changing size of diameter
5) Material used should strong enough to oppose the wind tunnel

Table 6: Using vehicle as medium to generate air

Speed (m/s)	Time of opening (s)	Reliability
0	0	Not opening
10	5	Slightly unstable
20	4	Stable
30	3	Very stable
40	3	Stable
50	2.5	Slightly unstable
60	2.2	Very unstable
70	0	Collapse

Table 7: Drop testing (50 feet)

Shape	No of string attached	Diameter (corner to corner)	Time from release to landing (ft/sec)	Reliability
Circle	4	120 cm	12.63	Unstable
Circle	8	120 cm	11.39	Unstable
Rectangular	4	100 cm	14.55	Unstable
Hexagon	6	70.4 cm	10.33	Stable
Hexagon	6	80.64 cm	8.33	Very Stable

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Autonomous Flight Navigation System acquire lots of engineering skills starting from the conceptual ideas & design followed by integration of circuits and implement testing to verify the actual operation in the system.

“Cansat” with fly-back design comprises of several subsystems which are navigation subsystem, power subsystem and communication subsystem by using LCD display for display the output. Mini robots operates for determine distance between drop zone to launching point. It will move towards launching point and terminate the operation once completed the missions.

Payload designation with accurate numerical calculation capable to avoid the payload crash once landed to the earth. Integration between hardware and software can serve the best platform for nano-satellite operates autonomously.

5.2 Recommendations

"Cansat" development project give real experiences and hands-on project need to be implemented to ensure that every parts of "Cansat" successfully operate. To improve the project in future, payload should be equipped with barometer / pressure sensor in order getting accurate height level or position from sea level rather than using GPS measurement. So that parachute can be deployed instantaneously once payload lifts up to 150 meters to the sky.

Other than that, the usage of dry cell for power consumption is not good solution since the satellites need to be as light as can to avoid overweight throughout the operation conducted. Dry cells give best option at this time to save cost. Power subsystem can use clock cell instead of using dry cell so that size and weight of payload can be reduced by one third from previous design.

Integration compass sensor with mini robot capable give extra advantages to fulfill the mission moving towards certain point without any human intervention. It means that mini robot able to identify the direction of targeted places before moving on. Lastly, project will be more successful if all hardware and software problem can be encounter.

REFERENCES

[1] Nobutada Sako, Yuichi Tsuda, Shuichiro Ota et al (2001), *Cansat Suborbital Launch Experiment – University Educational Space Program Using Can Sized Pico-Satellite,* Acta Astronautica, volume 48, Issues 5-12, March – June 2001, pages 767-776

[2] John Vogel, Mike Newton, Lee Cross (2004), FASTRAC – High Altitude Balloon Test Final Report (Electronic version), University of Texas, Department of Aerospace Engineering Mechanics

[3] 2ND IEEM International Cansat Competition, Feb 10,2009, Retrieved from http://cansat.leem.es/about/competition-categories

[4] Ivan Galysh (2004,July), *Lesson 1-Introdcution to Cansat,* retrieved from Federation of Galaxy Explorers, http://www.angkasa.gov.my/siswasat/document/lesson _1_Introduction to Cansat.pdf

[5] Yasuhiro Kusakawa & Shinichi Nakasuka (2007,Feb 2003), Cansat Activities in University of Tokyo – Excellent Training for Real Satellite Project (Electronic version), University of Tokyo

[6] Matunaga, S.Yoshihara, K.Suginia et al, "Titech Micro-Satellite Model:Cansat for Suborbital Flight", Aerospace Conference Procedures, 2000 IEEE

[7] Jawhawk Engineering Design Laboratory (20070, Overview of Cansat Imaging System, The University of Kansas

[8] Garmin GPS manufacturer,Feb 10,2009, retrieved from

http://www8.garmin.com/aboutGPS/

[9] *PMB-248 Parallax GPS Receiver Schematic*, August 2005, retrieved from

http://www.parallax.com/Portals/0/Downloads/docs/prod/sens/PMB-248%20GPS%20Receiver_A%20Schematic.pdf

[10] Ken hung (2005), GPS Receiver Module (Electronic version), Polstar Technologies Inc

[11] *Calculate distance, bearing & more between two latitude & longitude points*, Retrieved August 3, 2009 from

http://www.movable-type.co.uk/scripts/latlong.htm

[12] *User manual Robokits India*, retrieved July 27, 2009

http://robokits.co.in/documentation/robokoits serial LCD.pdf

[13] J.R Brohm (2004, September 4), *The Mathematics of Flat Parachutes*, retrieved July 12,2009 from

http://www.rocketshoppe.com/info/The Mathematics of parachute.pdf

[14] M.Mazidi, Rolin McKinley & Danny Cansey (2008), *PIC Microcontroller and Embedded System Using Assembly and C PIC 18*,New Jersey: Pearson International Edition

[15] Fred Eady (2004), *Networking & Internetworking With Microcontroller*. Oxford, UK:Newnes

[16] Andrew R.Chinnon & Brian D.Kaplinger (2009), *Optimizing ram-air parachute design to maximize lift production* (power point slides). Retrieved from http://www.home.eng.iastate.edu/ramair-presentation.pdf

[17] J.R Brohm (2004, September 4), *The Mathematics of Flat Parachutes*, retrieved July 12,2009 from http://www.rocketshoppe.com/info/The Mathematics of parachute.pdf

[18] Alfredo Necochea H, Bernardo, Gerrado Gruz et al (2008), *Cansat Competition 2008 Final Presentation* (power point slides), retrieved from Instituto Technologico Estudios de Monterrey, Campus Cindad de Mexico http://www.slideshare.net/astrosociety/cansat-2008-itesm-mexico-city-final