Tishk International University
Engineering Faculty
Mechatronics Engineering Department

Avionics

TOPIC: Unmaned Arial Vehicles

Week7_Lecture7

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Objectives

- **THE UNMANNED AERIAL VEHICLES (UAV) ARE OF GREAT SIGNIFICANCE IN MODERN DAY TECHNOLOGY AND FIND APPLICATIONS IN DIVERSE APPLICATIONS SUCH AS**

- TARGET AND DECOY
- RECONNAISSANCE
- COMBAT
- RESEARCH AND DEVELOPMENT
- CIVIL AND COMMERCIAL

UAV Vs Drone

- **UAV**

- IT COMPRISES OF A NUMBER OF SUBSYSTEMS WHICH INCLUDE THE AIRCRAFT(UAV), ITS PAYLOADS, CONTROL STATION(S),LAUNCH AND RECOVERY SUBSTATIONS, COMMUNICATION SUBSYSTEMS ETC.
- SYSTEM IS DESIGNED FROM ITS CONCEPTION TO BE OPERATED WITHOUT AIRCREW.
- A UAV HAS SOME DEGREE OF "AUTOMATIC INTELLIGENCE".
- IT IS ABLE TO COMMUNICATE WITH ITS CONTROLLER AND RETURN PAYLOAD DATA ALONG WITH ITS PRIMARY STATE INFORMATION- AIRSPEED, POSITION, HEADING ALTITUDE AND MOST IMPORTANTLY, HOUSEKEEPING INFORMATION.

- **DRONE**

- STANDS FOR DYNAMIC REMOTELY OPERATED NAVIGATION EQUIPMENT
- A DRONE IS REQUIRED TO FLY OUT OF SIGHT OF THE OPERATOR, BUT HAS ZERO INTELLIGENCE.
- IT IS MERELY LAUNCHED INTO A PRE-PROGRAMMED MISSION ON A PRE-PROGRAMMED COURSE WITH AN RTL COMMAND.
- IT DOES NOT COMMUNICATE AND THE RESULTS OF THE MISSION ARE USUALLY OBTAINED UNTIL ITS RECOVERED BACK.

Types of UAV

- Fixed wing UAV
- Quad copter
- Hexacopter
- Octa copter

Classification based on Range & Endurance:

- **-HALE** – High altitude long endurance.
- Over 15 000 m altitudeand 24+ hr endurance.

- **-MALE –** Medium altitude long endurance.
- 5000– 15 000 m altitude and 24 hr endurance.

- **-TUAV–** Medium Range or Tactical UAV with range of order between 100 and 300 km.
- https://sci-hub.se/10.1109/ISSNIP.2004.1417507

PAYLOADS OF UAV

- **SENSORS:-**
- OPTICAL SENSORS
- EOIR SENSORS
- COLOR THERMAL IMAGER
- LIDAR
- SAR

- **ANTENNAS:-**
- **DIRECTIONAL**
- **OMNIDIRECTIONAL**
- **FOLLOW ME OPTION USING GPS**

- **AUTOPILOT**
- **GIMBAL CONTROLLED CAMERA**

COMMUNICATION SYSTEM USED IN UAV

- **THERE ARE VARIOUS TYPES OF COMMUNICATION SYSTEMS BEING USED FOR OPERATION OF UAV'S SUCH AS**

❑ TELE COMMAND

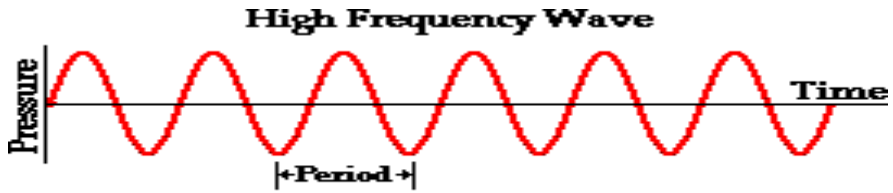
❑ TELEMETRY(2.3GHZ)

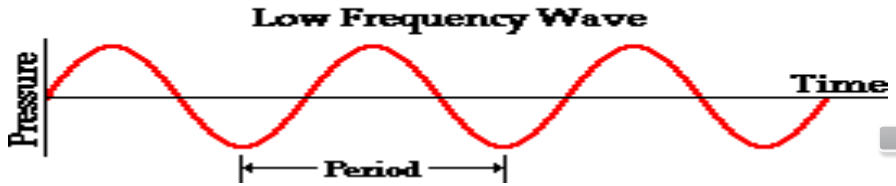
❑ TELEVISION(5.8GHZ)

❑ SATCOM

FOR A/V SIGNALS, THE FREQUENCY RANGE IS-

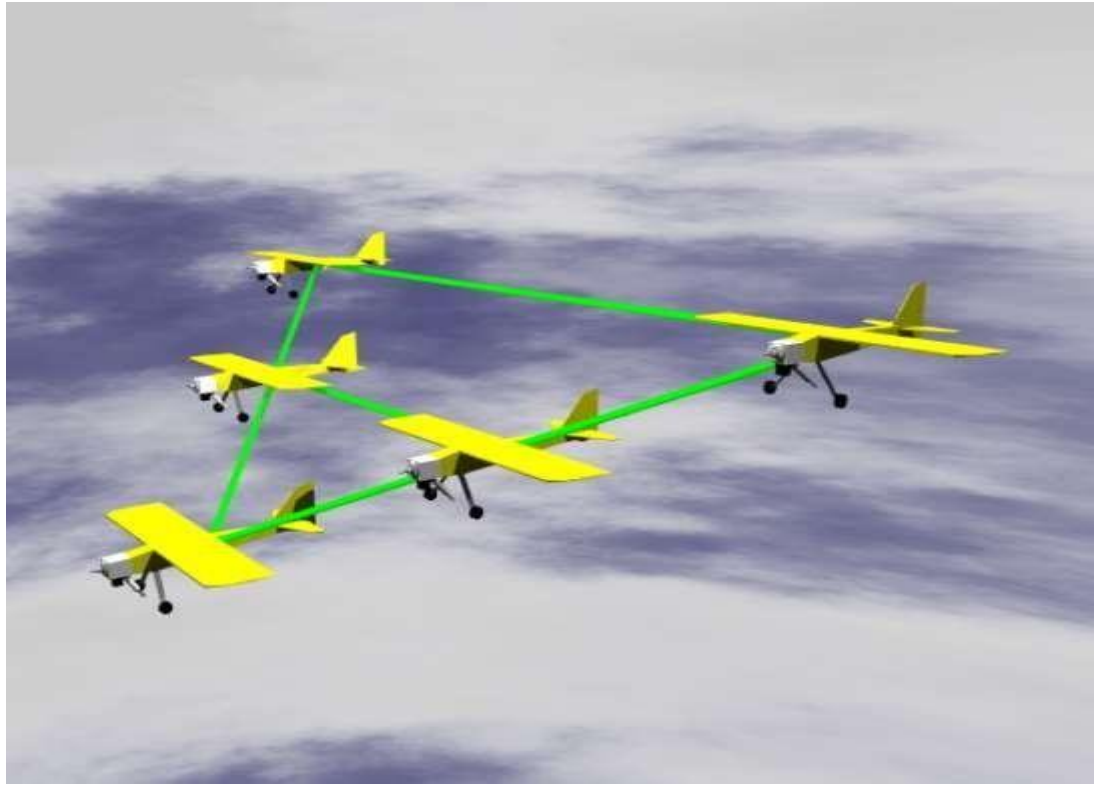
- 433MHZ-900MHZ(LOW FREQUENCY, AUDIO SIGNALS)
- 1.2-5.8GHZ (HIGH FREQUENCY, LIVE FEED VIDEOS)





BASED ON THE OPERATION AND MISSION REQUIREMENTS

1. **LASERS ARE USED FOR LARGE DATATX WITH LOWRX RANGE.**
2. **OPTICAL FIBERS ARE USED BETWEEN GROUND STATIONS**
3. **RADIO FREQUENCY (HF AND LF) USED.**
   - **HF IS USED FOR HIGH DATA RATES BUT PROPAGATES LESS**
   - **LFUSED FOR LESSDATA RATES BUT WITH IMPROVED DATA RATE**
4. **FSO: FREE SPACE OPTICS USED FOR DIRECT LINK, WITH NO INTERFACE REQUIRED. HAS AN INCREASED BIT RATE AND WORK ONLY UNDER GOOD ATMOSPHERIC CONDITIONS**



Multi agent communication

ANTENNA SYSTEM FOR UAV

- BASED UPON THE TYPE AND MISSION SPECIFICATIONS 3 TYPES OF ANTENNAS ARE BEINGUSED:-

  ❖ DISH ANTENNA

  ❖ PARABOLIC ANTENNA

  ❖ YAGI ANTENNA(HIGH GAIN, DIRECTIONAL ANTENNA)

- **LINEAR POLARIZED, HIGH GAIN ANTENNAS ARE PREFERRED FOR UAV MODELS.**

- **THE UAV KEEPS CHANGING ITS DIRECTION AND ORIENTATION, HENCE A GIMBAL SYSTEM IS USED TO MANAGE THE ORIENTATION.**

- PATH LOSSES

- PL=117+20LOG10F-20LOG10(HT*HR)+40LOG10D

{PL=PATH LOSS(DBM), F=O/P FREQ IN MHZ, HT,HR=HT OF TX AND RX ANT IN FT,D=LINE OF SIGHT IN MILES}

- DIVERSITY CONTROLLER IS ALSO USED IN THE ANTENNA SYSTEM TO PROVIDE MULTIPLE PORTS FOR ANTENNA CONNECTION.

- IT CONSISTS OF A SINGLE RECEIVER, BUT HAS MULTIPLE SLOTS FOR MORE THAN 2 ANTENNAS TO CONNECT FOR BETTER SIGNAL TX AND RX.

Electric Propulsion System

ELECTRIC MOTOR

- BRUSHLESS AC MOTOR USED(HIGH TORQUE AND MORE EFFICIENT)
- BRUSHED DC NOT CONSIDERED AS BOTH THE BRUSHES AND COMMUTATOR WEAR DOWN, IS LESS EFFICIENT
- MOTOR OUTPUT POWER {W= TORQUEX2PXRPM/60}
- RATINGS: 500KV(FOR 1V OF SUPPLY, MOTOR WOULD PROVIDE 500RPM)
- SPECS: 2216-06(2100)

FIRST 2 DIGITS TELL THE DIAMETER OF THE MOTOR IN (MM)

NEXT 2 GIVE THE HEIGHT OF THE MOTOR IN (MM)

2 NUMBERS AFTER (-) GIVE POLES OR NUMBER OF COILS PRESENT

LAST 4 DIGITS GIVE THE KV RATING

CALCULATING THE FLIGHT TIME?

BATTERIES

- LITHIUM-ION POLYMER BATTERIES OF LIGHT WEIGHT, LARGE CAPACITY, HIGH DISCHARGE RATE AND GOOD ENERGY STORAGE TO WEIGHT RATIO.
- FOR EXAMPLE, A BATTERY WITH SPECS OF 1000MAH~1AMP

IF THE UAV HAS COMPONENTS THAT CONSUME 2AMP CURRENT, THE FLIGHT TIME IS SIMPLY:

30MIN

Auto pilot of UAV(ardupilot)

- **ArduPilot** (also **ArduPilotMega** - APM) is an open source unmanned aerial vehicle (UAV) platform, able to control autonomous multicopters, fixed-wing aircraft, traditional helicopters and ground rovers.
- The system was improved to replace thermopiles with an Inertial Measurement Unit (IMU) using a combination of accelerometers, gyroscopes and magnetometers.

https://www.sparkfun.com/products/retired/9710

❖ Features of Ardupilot:-

- Programmable 3D way points
- Return to launch
- inflight reset
- fully programmable actions at waypoints
- Stabilization options to negate the need for a third party co-pilot
- Fly By Wire mode
- Optimization of 3 or 4 channel airplanes.
- Flight Simulations

Ardupilot 2.8 C++ Process Flow

N Harris 2012

The init_ardupilot function processes everything we need for an in-air restart
We will determine later if we are actually on the ground and process a ground start in that case.

Also in this function we will dump the log if applicable based on the slide switch

init_ardupilot

Ensure Loop is Running 50 Hz

// 50Hz = 20 Millis

Is it 50Hz

Fast Loop Run BELOW FIRST

Read_Radio() (RadIo.pde)

Read_Air_Speed()

Decode_GPS()

Calc_altitude_error()

Calc_bearing_error()

Update_current_flight_mode()

Manual Mode

Output_manual

NOT Manual Mode

Calc_speed_scaler()

Stabilize_pitch()

Stabilize_roll()

Stabilize_rudder() (IF ENABLED)

Send_message() telemetry

Main Loop Event

Medium Loop Medium_loop_counter = 0

// This is the start of the medium (10 Hz) loop pieces

Case 0 (Medium_loop_counter ++)

Case 1 (Medium_loop_counter ++)

Case 2 (Medium_loop_counter ++)

Case 3 (Medium_loop_counter ++)

Case 4 (Medium_loop_counter = 0)

Update_GPS

Update Navigation Timer

unused

telemetry

Medlu_event_loop

Navigate() Navigate Planes desired bearing

Update navigation()

Update crosstalk()

CASE RTL

CASE LOITER

CASE LAND

CASE AUTO

CASE TAKEOFF

Update nav_bearing based upon loiter radius

update_crosstrack ()

Calculate if to HOLD course or if plane has landed

calc_bearing_error ()

Check waypoint not missed

HOLD Course

Nav with bearing error

IN AIR

Reset_control_switch()

WP Distance < 0 Do Nothing

(wp_distance <= wp_radius) || (waypoint_event==EVENT_WILL_REACH_WAYPOINT)

reached_waypoint();

update_crosstrack ()

ADJUST loiter

reached_waypoint();

// This is the slow (3 1/3 Hz) loop pieces

Slow_loop (slow_loop_timer ++0)

Case 0 (slow_loop_timer ++)

Case 1 (slow_loop_timer ++)

Case 2 (slow_loop_timer =0)

NOT USED

read_control_switch()

read_battery ()

NOT USED

Adjust Pitch for landing

calc_nav_throttle()

calc_nav_pitch()

calc_nav_roll();

crash_checker()

ADJUST PITCH

Air Sspeed Sensor CALC

GPS only CALC

calc_nav_roll();

Constrain ROLL and PITCH of aircraft

Case RTL Break

Case LOITER Break

Case AUTO

Case TAKEOFF

Case LAND

Case FLY BY WIRE A

Update_current_flight_mode()

Case FLY BY WIRE B Requires airspeed sensor

Constrain ROLL of aircraft

Airspeed CALCs

calc_nav_pitch()

calc_nav_throttle()

Case CONFIG

Help Configure Air Sensor

Case STABILIZE

nav_roll = 0; nav_pitch = 0;

// throttle is passthrough

Case CIRCLE

// we have no GPS installed and have lost radio contact // or we just want to fly around in a gentle circle w/ no GPS

nav_roll = HEAD_MAX / 3; nav_pitch = 0;

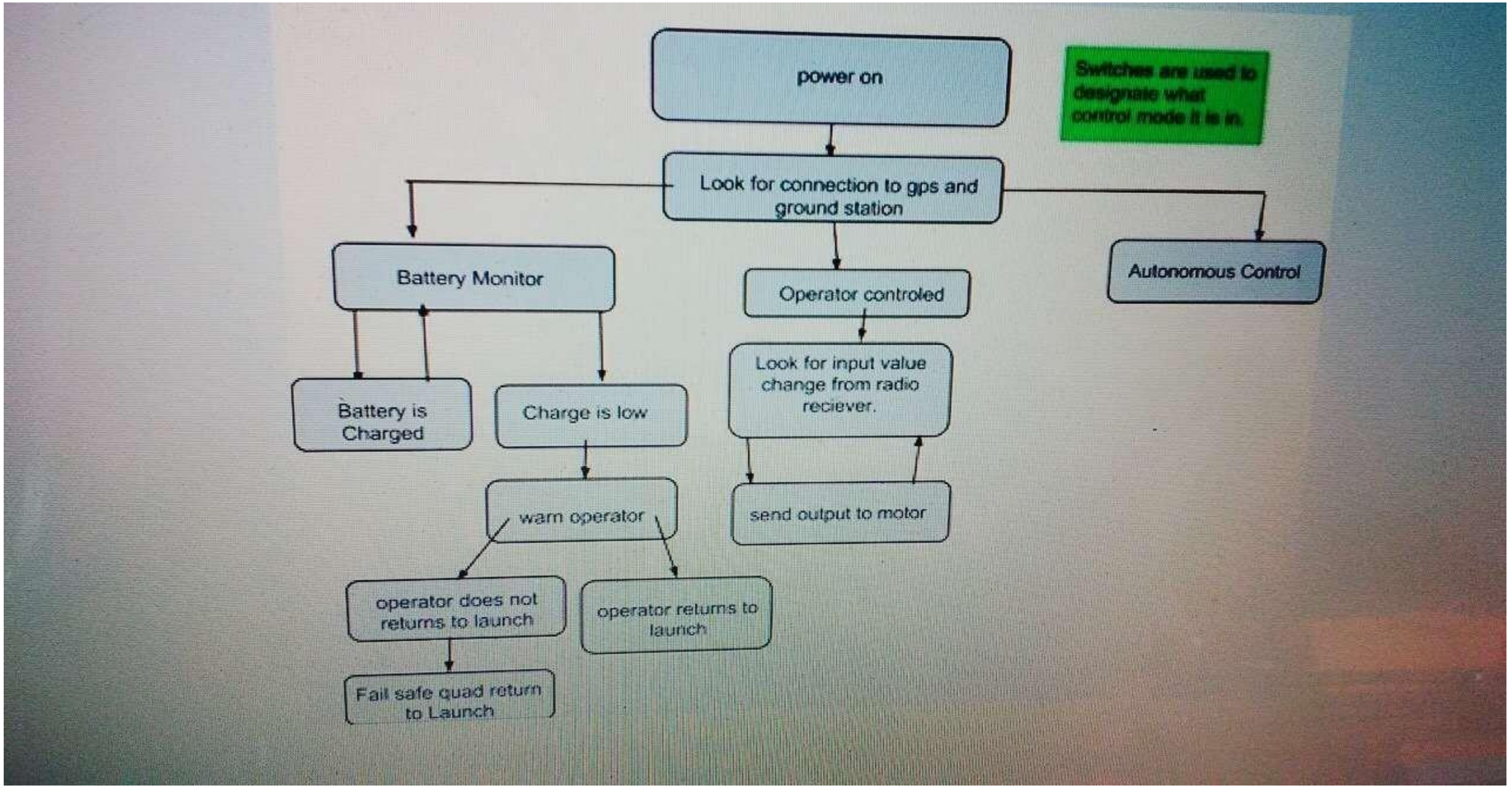
THROTTLE SET CRUISE

Case MANUAL

SERVO OUTPUT

For SIMULATION ONLY

Working of Ardupilot



Mission Planner

Mission Planner is a ground control station for Plane, Copter and Rover. It is compatible with Windows only. Mission Planner can be used as a configuration utility or as a dynamic control supplement for your autonomous vehicle.

few things you can do with Mission Planner:

- Load the firmware (the software) into the autopilot (APM, PX4…) that controls your vehicle.
- Setup, configure, and tune your vehicle for optimum performance.
- Plan, save and load autonomous missions into you autopilot with simple point-and-click way-point entry on Google or other maps.
- Download and analyze mission logs created by your autopilot.
- Interface with a PC flight simulator to create a full hardware-in-the-loop UAV simulator.
- With appropriate telemetry hardware you can:
  - Monitor your vehicle's status while in operation.
  - Record telemetry logs which contain much more information the the on-board autopilot logs.
  - View and analyze the telemetry logs.
  - Operate your vehicle in FPV (first person view)

Attitude

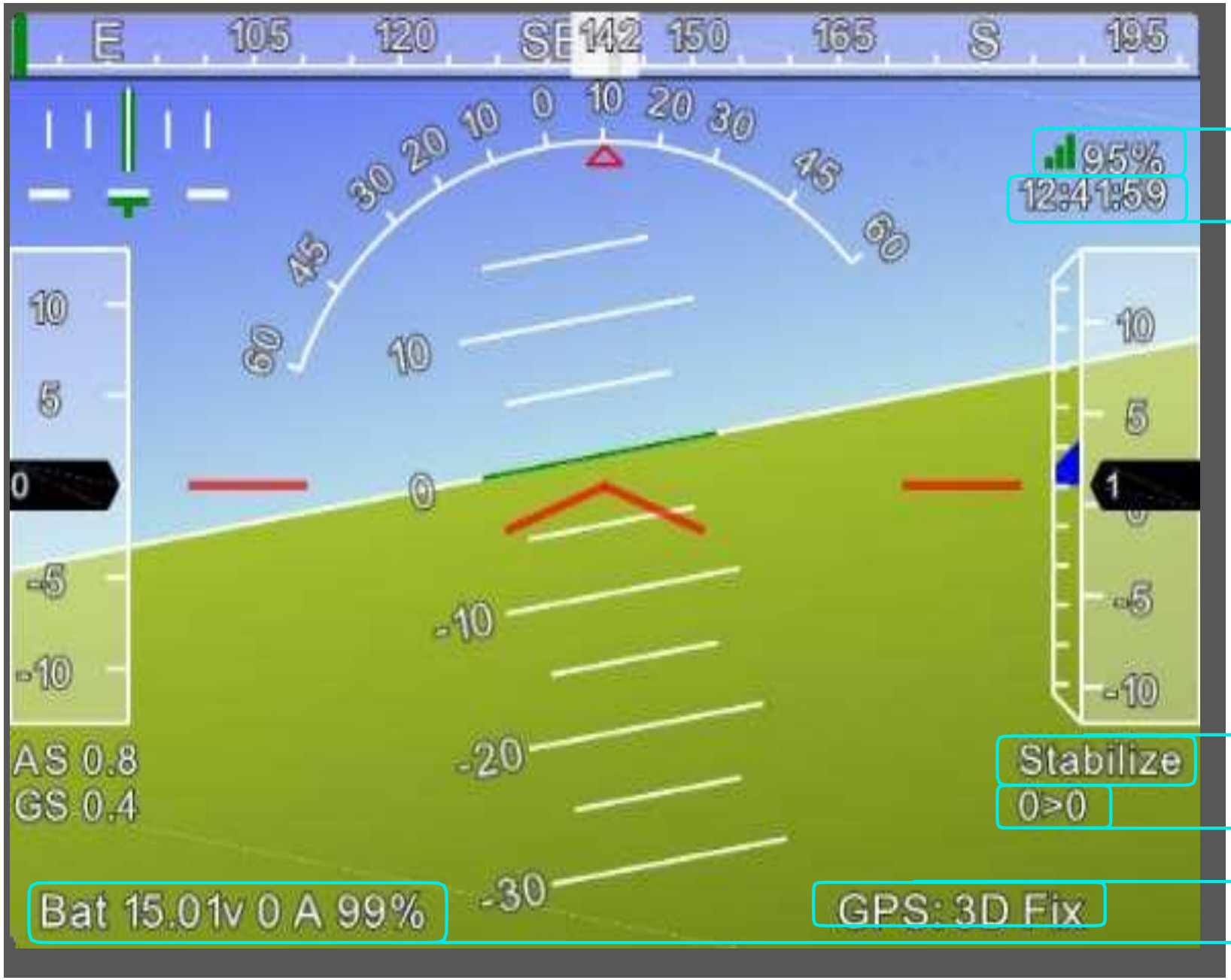
Heading Direction

Bank Angle

Altitude (black) and rate of climb (blue bar)

Ground speed

status



Telemetry signal

GPS time

Currently enabled mode

Distance to current waypoint > current waypoint number

GPS status

Battery status

location

Current heading

Direct path to current waypoint

GPS-reported direction of travel

Actual flight path

Latitude & longitude

Altitude


Crosstrack error and turn rate (T)
Heading direction
Bank angle
Wireless telemetry connection (% bad packets)
GPS time
Intended heading (including crosstrack correction)
Current heading
Direct line to current waypoint
Artificial Horizon (remember, this is the reverse of the aircraft's bank angle)
Air speed (Ground speed if no airspeed sensor is fitted)
Air speed
Ground speed
Battery status
Altitude (blue bar is rate of climb)
GPS status
Desired turn radius
Track of recent travel
GPS reported altitude
GPS reported direction of trave (usually lags)
alt
87.35
groundspeed
15.38
wp_dist
49
GPS: 3D Fix
Current autopilot mode
Latitude
Longitude
Altitude

Live project

Type	Fixed wing
Weight	0.7 kg (1.54 lbs)
Wingspan	.875 m
Wing area	.118 m^2
Material	Chloro vinyl sheet
Propulsion	Electric pusher propeller; brushless 700 Wmotor
Battery	12 V
Camera	Go pro cam

CALCULATIONS FOR FIXED WING UAV

1. Weight Estimation :

Servo – 8.5g x 4 = 34g
Motor – 52g
ESC – 25g
Propeller – 30g
Battery – 60g Landing Gear – Assuming as 50g Model Weight – Assuming as 400g
Total Weight – 651g

Approximate the weight to be 700grams for safer side.

(Kg x 2.2 = Lbs.)
700grams = 0.7 kg -> 0.7*2.2 = 1.54 lbs.

2. Wing Loading :

For UAV's, wing loadings will be ***1-3 lb./ft2***
Wing Loading = W/S
W= weight
S = Surface Area
Find the surface Area from the above equation **Example : taking Wing loading to be 1.2.**
1.2 = 1.54/S
S=1.28 Ft2

Feet square to meter square: 1.28 *0.304* 0.304 = 0.118 m2.

3. Aspect Ratio :

Assumption: The Aspect ratio must be greater than 6.
A.R = b2/S
B=Span
S=Surface Area
Find the Span from the above equation.
Example : Take aspect ratio to be 6.5
A.R = b2/ S 6.5 = b2/ 0.118 => b2 = 0.767 => b = 0.875 m
=> Span, b = 0.875meters.

4. Wing :

Assume Rectangular wing, so Area = span x Chord Find the chord from the above equation.
Example : Area = Span x Chord

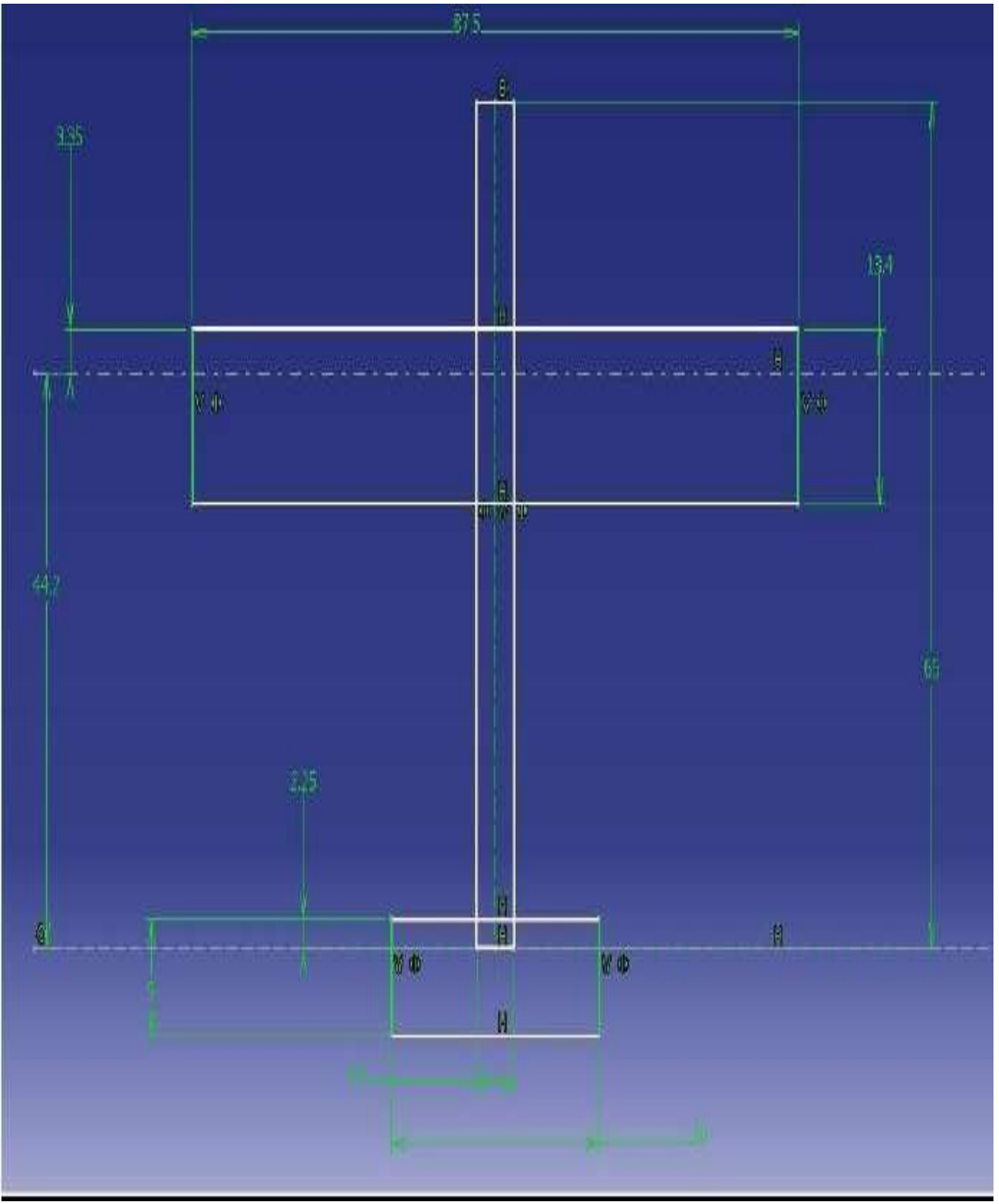
⇨

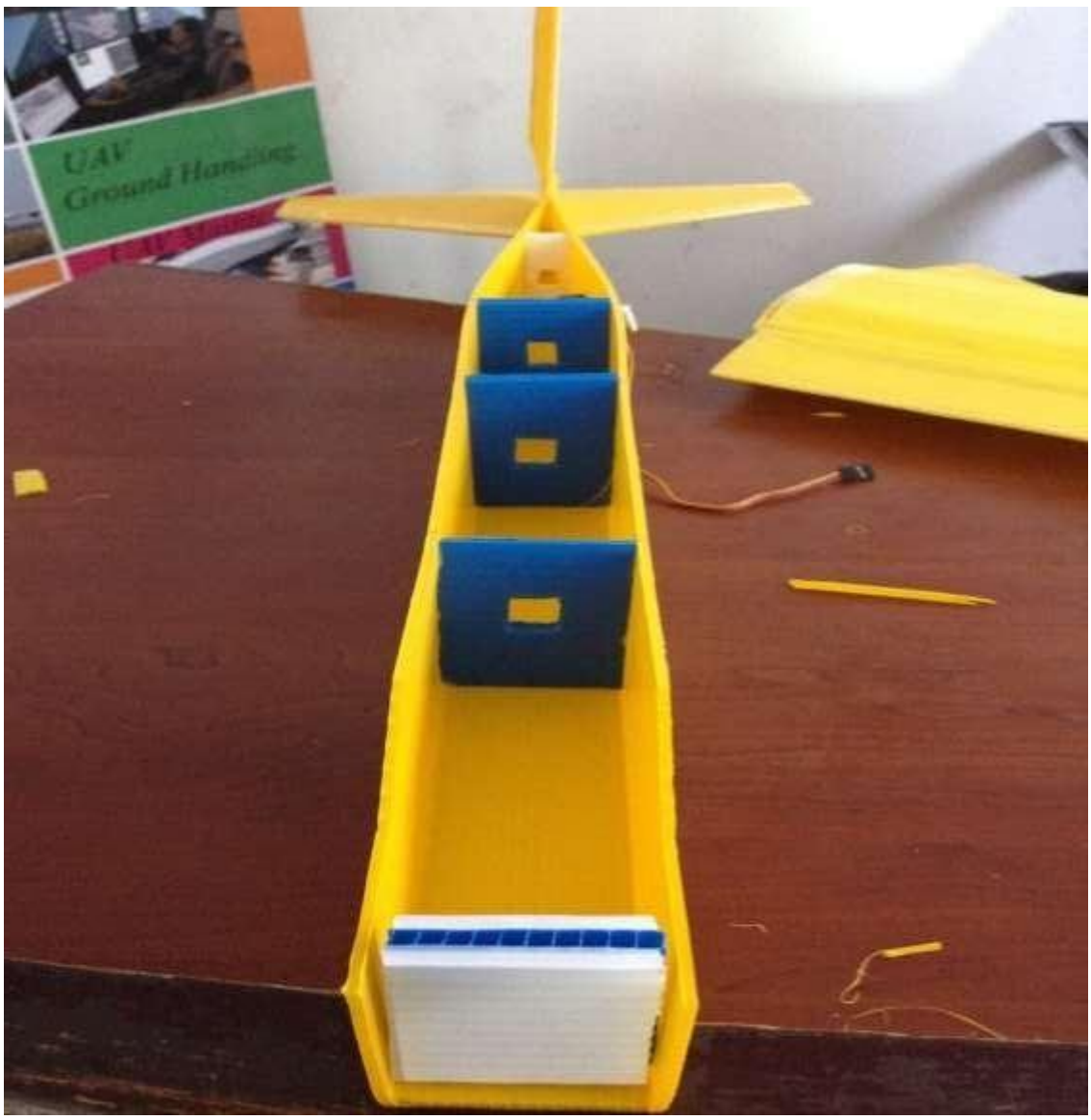
S = b x c

0.118 = 0.875 x C C = 0.134 Meters

Project model Samples

- Kindly Do Real Model and practice UAV as you are mechatronics Students.
- Open Source Link
- https://www.dronedeploy.com/
- Mission planner
- https://ardupilot.org/planner/docs/mission-planner-installation.html
- http://wiki.paparazziuav.org/wiki/Main_Page
- https://www.dronecode.org/
- https://www.librepilot.org/site/index.html


87.5
3.35
13.4
44.7
2.45


UAV
Ground Handling


Thank You!

Your Queries Please!!!