

Flight Controller and Ground Station Software

Michael W. Gabriel Kellan Shafer Vega Rothfus

Merriam Powell Biennial Conference Flagstaff, AZ 11 September 2017



Flight Modes vs Flight Plans



Flight Modes

- Determines flight behavior of copter and extent of operator control
- 14 built in flight modes
- Can be switched during flight

Flight Plans

- Applicable in the auto flight mode
- Pre-determined before takeoff and pre-loaded onto copter
- Generated with GCS user interface using interactive map



Flight Modes: Stabilize



- Most commonly used flight mode
- Pilot has control of vehicle's altitude, pitch, roll and yaw
- Throttle is adjusted based on title angle of the vehicle
 - Increased vehicle tilt increases throttle sent to vehicle

Flight Modes: Stabilize



- When pilot releases control of pitch or roll, vehicle automatically levels itself with respect to horizon
- When pilot releases yaw vehicle maintains its heading





Flight Modes: Loiter



- Mode used to help automatically maintain an operator determined vehicle altitude
- Horizontal location can be determined by pilot input, but vehicle will maintain positon once roll and pitch control sticks are released
- Altitude controlled by manual input
 - Vehicle will maintain altitude if throttle input is unchanged
- Vehicle's yaw can be controlled by pilot



Flight Modes



Auto

- Begins the pre-programmed autonomous flight
- Allows manual yaw control but all other parameters are locked
- Requires GPS signal

Land

- Brings the copter straight down at it's current location
- Usually used as a manual emergency land

Flight Modes



RTL (Return-to Launch)

- Automatically returns the vehicle to the take-off location and ulletlands the vehicle
- **Requires GPS signal** •



Failsafes



- Radio Failsafe: vehicle will return to launch if lost connection occurs during flight
- Ground Control Station Failsafe: vehicle will return to launch if lost connection occurs during flight (unless vehicle is in auto mode where mission will just continue)
- Software arming mechanism prohibits motors from operating until internal vehicle parameters are verified and operator manuals arms copter



Failsafe



- Manual Failsafe
 - Easily able to change into Land or RTL flight mode
 - Ability to take manual control of the vehicle
 - Switch on copter must be pressed before motors will arm



Switch to change flight modes -



Ground Control Station: Overview



- GCS used: Mission Planner
- Software interface that communicates with the vehicle over 915 MHz wireless telemetry
- System showcases real-time data from vehicle and provides interface to adjust vehicle parameters





Ground Control Station: Overview



Allows user to define autonomous flight plans and calibrate • hardware

Mission Planner 1.3.49 build 1.1.6410.20222	- 🗇 🗙 🔤 Mission Planne	er 1.3.49 build 1.1.6410.20232 APM:Copt	er V3.6-dev (09407)	33)		o ×
		í 🔗 🦽 🚅		<u>ايم</u> ا	00/43 ~ 57600 - Stats	
Distance 0 9078km	Zoom Action » Flight Modes	Command	Value Units	Options	Desc	ad from file
Perce 106 (7 m A2-3) Here 1166 (7 m	GED • 35.173454 - 111658254 SRTM 2109.73m GeoFence	EK2_WIND_PSCALE	0.5	0010	This controls how much the process noise on the wind states is increased when gaining or losing altude to take into account changes in wind speed and direction with altude. Increasing this parameter increases how rapidly the wind states adopt when changes altude. but does make wind vectors estimation noise:	Save to file
8 8 1 1	Grid Mew.KML Extended Tun	EK2_YAW_I_GATE	300	100 1000	This sets the percentage number of standard deviations applied to the magnetometer your measurement innovation consistency check. Decreasing it makes it more likely that good measurements will be rejected. Increasing it makes it more likely that bad measurements will be accepted.	hite Params
	GoogleSateliteMa	EK2_YAW_M_NSE	0.5 rad	0.051.0	This is the RMS value of noise in yow measurements from the magnetometer. Increasing it reduces the weighting on these	neare Parama
	Status: loaded tiles Standard Para Load WP File Advanced Para	ams EK3_ENABLE		0.Disabled 1:Enabled	Investigation as This enables EPF3. Enabling EVF3 only makes the maths run, it does not mean it will be used for flight control. To use it for flight control set AHRS_EVF_TYPE-3. A rebost or restart will need to be performed after changing the value of EVC_ENABLE for it to advanting.	
	Full Paramete	rlist		0 Normal Start-up 1 Start-up in	A D	t with no scaling
	Loaded lawn mover with Full Paramete	ESC_CALIBRATION		ESC Calibration mode # throttle high 2:Start-up in ESC Calibration mode regardless of throttle 3:Start-up and automatically without ESC # Disturbled	Controls whether AnduCoptor will enter ESC calibration on the next restart. Do not adjust this parameter manually.	hs+_AC34 +
	Pianie	FENCE_ACTION	1	0.Report Only 1:RTL or Land	What action should be taken when fence is breached	set to Default
	White Wirs	FENCE_ALT_MAX	100 Meter	10 1000	Maximum atitude allowed before geofence triggers Search	sh
	Hame Location	FENCE_ENABLE		0 Deabled 1 Enabled	Allows you to enable (1) or deable (0) the fence functionality	
	Let 35.173857	FENCE_MARGIN	2 Meter	1 10	Distance that autoplot's should maintain from the fence to avoid a breach	
	. Long (111.65695)	FENCE_RADIUS	300 Meter	30 10000	Orole fence radius which when breached will cause an RTL	
	Yolls At (abs) 9	FENCE_TOTAL	0	120	Number of polygon points saved in exprom (do not update manually)	
		FENCE_TYPE		0 None 1 Abbude 2 Orcle 3 Abbude and Orcle 4 Polygon 5 Abbude and Polygon 6 Orcle and Polygon 7 Ab	Enabled fence types held as bitmask	
		FLOW_BUS_ID			This is used to select between multiple possible bus IDs for some sensor types. For PX4Row you can choose 0 to 7 for the 8 possible addresses on the I2C bus.	
		FLOW_ENABLE		0 Dirabled 1:Enabled	Setting this to Enabled(1) will enable optical flow. Setting this to Disabled(2) will disable optical flow	
		FLOW_FXSCALER	0	-200 +200	This sets the parts per thousand scale factor correction applied to the flow sensor X axis optical rate. It can be used to correct for variations in effective faceal length. Each positive increment of 1 increases the scale factor applied to the X axis optical flow regring by 0.1%. Negative values reduce the scale factor.	
		FLOW_FYSCALER		-200 +200	This sets the parts per thousand scale factor correction applied to the flow sensor Y axis optical rate. It can be used to correct for variations in effective focal length. Each positive increment of 1 increases the scale factor applied to the Y axis optical flow reading by 0.1%. Negative values reduce the scale factor.	
And The set 6217 Test Start Head Start Test Start Head Start Start Start		FLOW_ORIENT_YAW	0	-18000 +18000	Specifies the number of centi-degrees that the flow sensor is yawed relative to the vehicle. A sensor with its X-axis pointing to the ocht of the vehicle X axis has a costitive yaw ande.	
Waypoints	¥.	FLOW_POS_X	m 0		X position of the optical flow sensor focal point in body frame. Positive X is forward of the origin.	
WP Radua Loter Radua Default At Relative → EVerty Height Ad Beliave A Bar Sone		FLOW_POS_Y	0 m		Y position of the optical flow sensor focal point in body frame. Positive Y is to the right of the origin.	
		FLOW_POS_Z			Z position of the optical flow sensor focal point in body frame. Positive Z is down from the origin.	
Command Colds I Lat Large Alt Colds Li Large Alt Colds Li Large Alt Colds Li Large Alt Colds Li Large Alt Colds Large Alt Large Large <thlarge< th=""> <thlarge< th=""> <thla< td=""><td></td><td>FLTMODE1</td><td>0</td><td>0.Stabilize 1:Acro 2:AtHold 3:Auto 4:Guided 5:Loter 6:RTL 7:Circle 9:Land 11:Dift 13:Spot 14:Rip 15:Auto Tune 16:PostHold 17:Brake 18:Throw 19:Avoid ADS8 20:Guided_NoGPS</td><td>Right mode when Channed 5 prom is c= 1220</td><td></td></thla<></thlarge<></thlarge<>		FLTMODE1	0	0.Stabilize 1:Acro 2:AtHold 3:Auto 4:Guided 5:Loter 6:RTL 7:Circle 9:Land 11:Dift 13:Spot 14:Rip 15:Auto Tune 16:PostHold 17:Brake 18:Throw 19:Avoid ADS8 20:Guided_NoGPS	Right mode when Channed 5 prom is c= 1220	
4 5 6 0 0 5 100 7 0 0 0 100 7 0 <td></td> <td>FLTMODE2</td> <td>0</td> <td>0 Stabilize 1 Acro 2 Att Hold 3 Auto 4 Guided 5 Lotter 6 RTL 7 Circle 9 Land 11 Dift 13 Sport 14 Rip 15 Auto Tune 16 PostHold 17 Brake 18 Themer 19 Aurol: ADSR</td> <td>Right mode when Channel 5 pixel is >1220, <- 1360</td> <td></td>		FLTMODE2	0	0 Stabilize 1 Acro 2 Att Hold 3 Auto 4 Guided 5 Lotter 6 RTL 7 Circle 9 Land 11 Dift 13 Sport 14 Rip 15 Auto Tune 16 PostHold 17 Brake 18 Themer 19 Aurol: ADSR	Right mode when Channel 5 pixel is >1220, <- 1360	



Ground Control Station: Heads-Up-Display





Distance to current waypoint ">" Current waypoint number



Acknowledgments

This work was supported by NSF Award 1556417 •



ARIZO

NORTHERN

Collaborators Paul Flikkema and Carol Chambers







QUESTIONS?

