How to make your own Quadcopter?

e-Yantra Team

Embedded Real-Time Systems (ERTS) Lab
Indian Institute of Technology, Bombay

IIT Bombay
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Agenda for Discussion

1. What do you need?
2. Hardware
3. Software/Firmware
4. Flight Modes
5. Intelligent Autopilot Stacks
6. Sample Configuration

What do you need?

1. Frame

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2. Propellers

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3. Motors

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4. Motor Drivers

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9. Software/Firmware

Frame

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Propellers

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Propellers





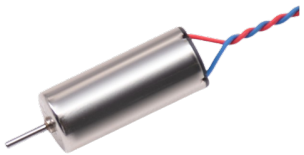

Motors

Brushed Motors

Brushless Motors

Motors

Brushed Motors



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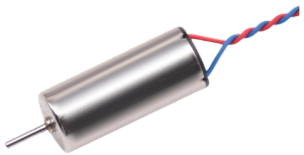

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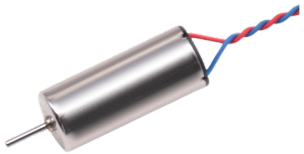

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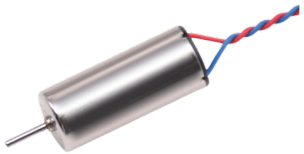

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Brushless DC motor drivers or Electronic Speed Controllers (ESC)

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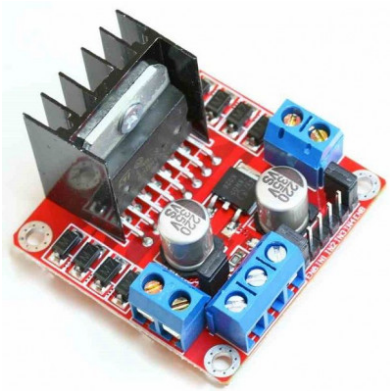

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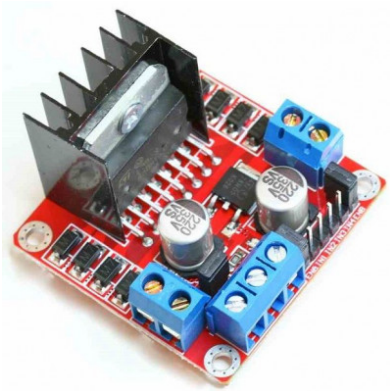

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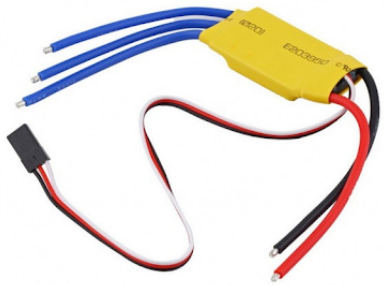

Flight Controller

A computer capable of running complex algorithms to control the aircraft.

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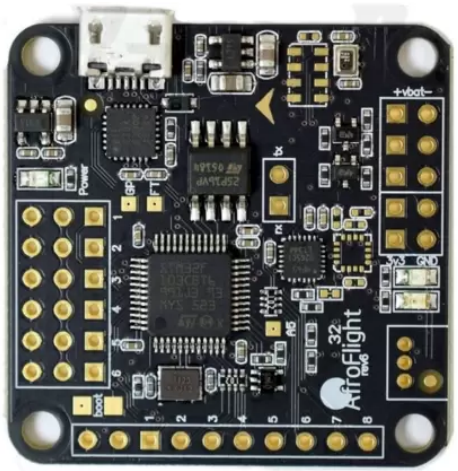

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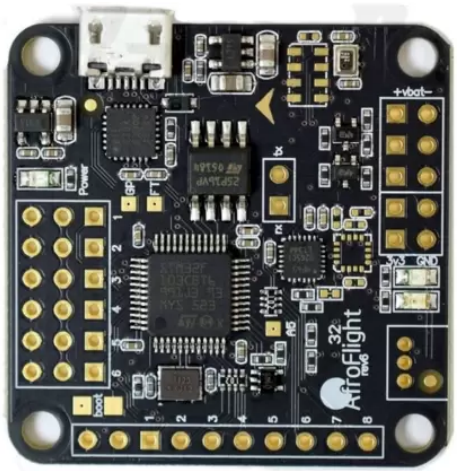

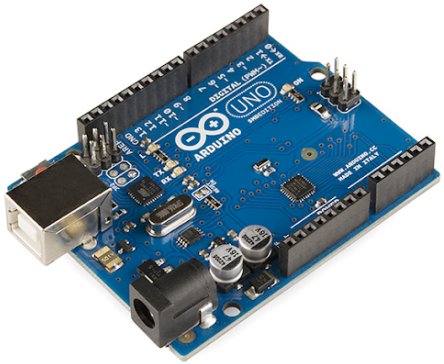

Remote Controller (RC) and Receiver

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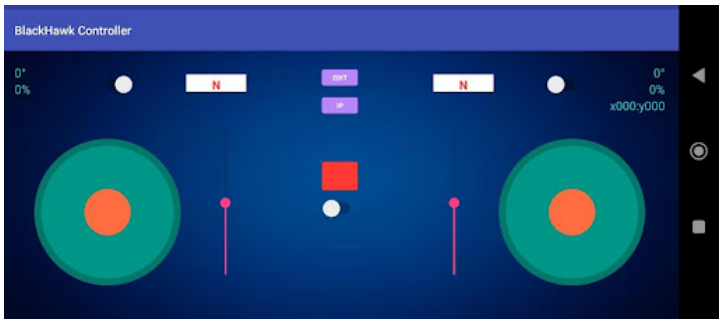

Global Navigation Satellite System (GNSS) receiver

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Battery

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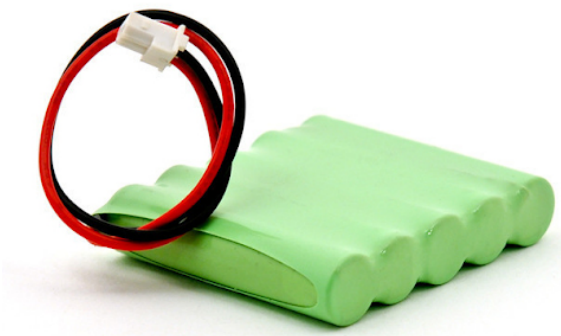

Firmware for flight controller

The software that runs on the flight controller board of a drone.

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- Powerful Safety Features

Ground Control Station (GCS)

A ground station is typically a software application, running on a ground-based computer, that communicates with your UAV via wireless telemetry.

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- Visualization and Mapping
- Data Recording and Analysis
- Communication and Connectivity

Ground Control Station (GCS)

QGroundControl

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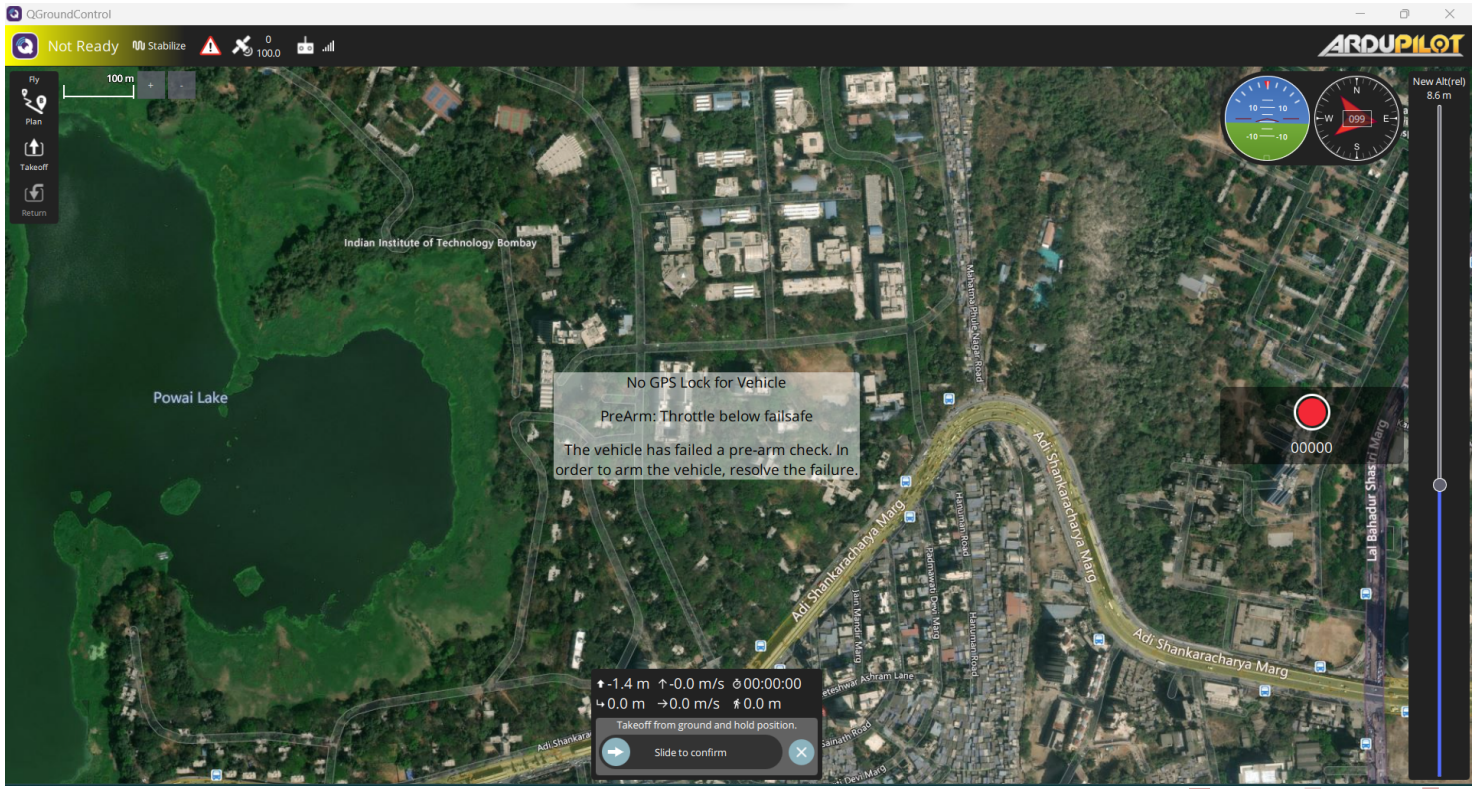

Ground Control Station (GCS)

Mission Planner

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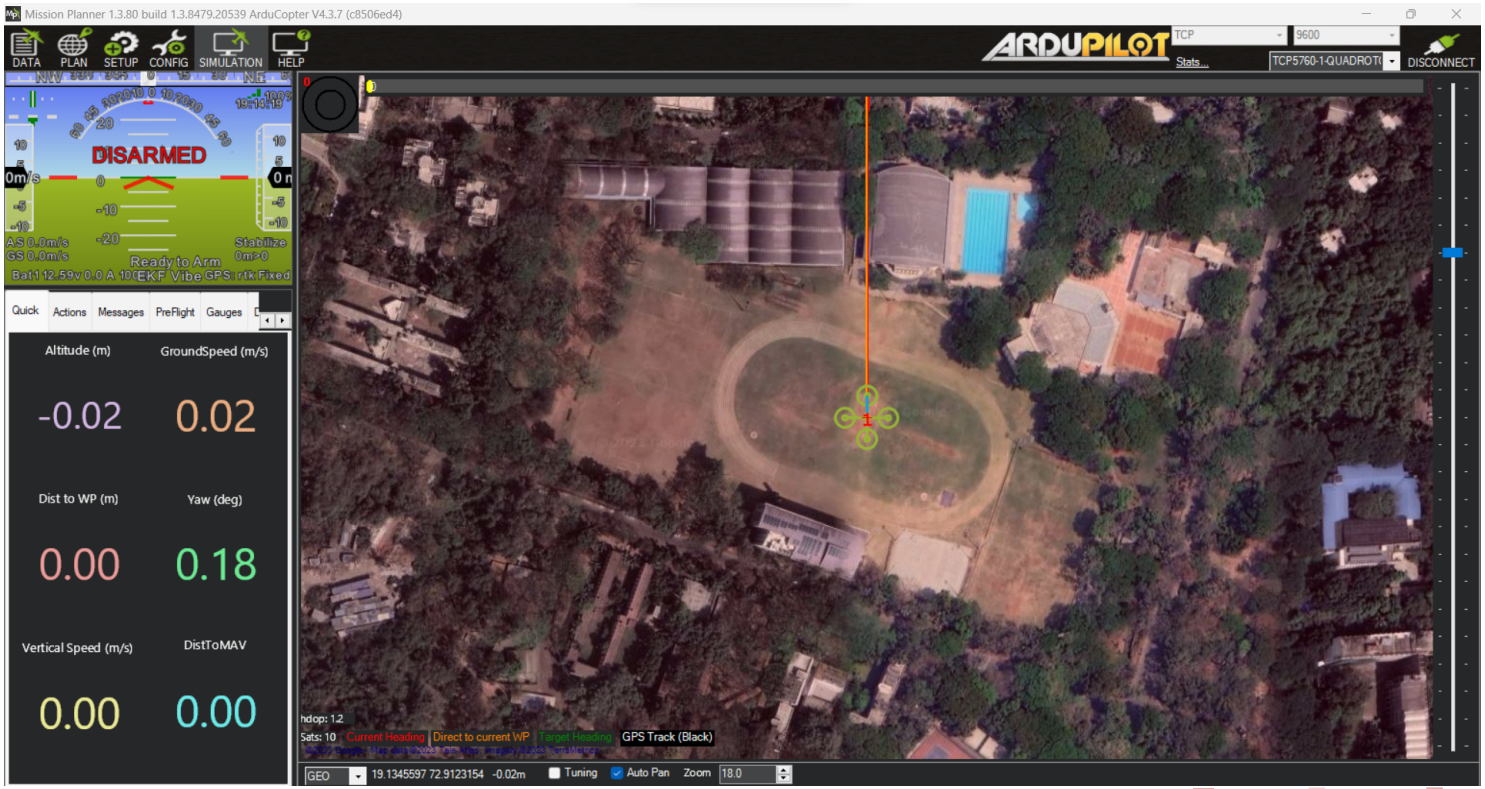

Flight Modes

1. Mission Mode
2. Offboard Mode

Mission Mode

Autonomous Mode / Waypoint Navigation

- This mode requires 3d position information (e.g. GPS)

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- This mode requires 3d position information (e.g. GPS)
- The quadcopter execute a predefined autonomous mission (flight plan) that has been uploaded to the flight controller
- The mission is created and uploaded using a GCS application like QGC or MP

Mission Mode

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- RC control switches can be used to change flight modes on the quadcopter
- The quadcopter must be armed before this mode can be engaged.

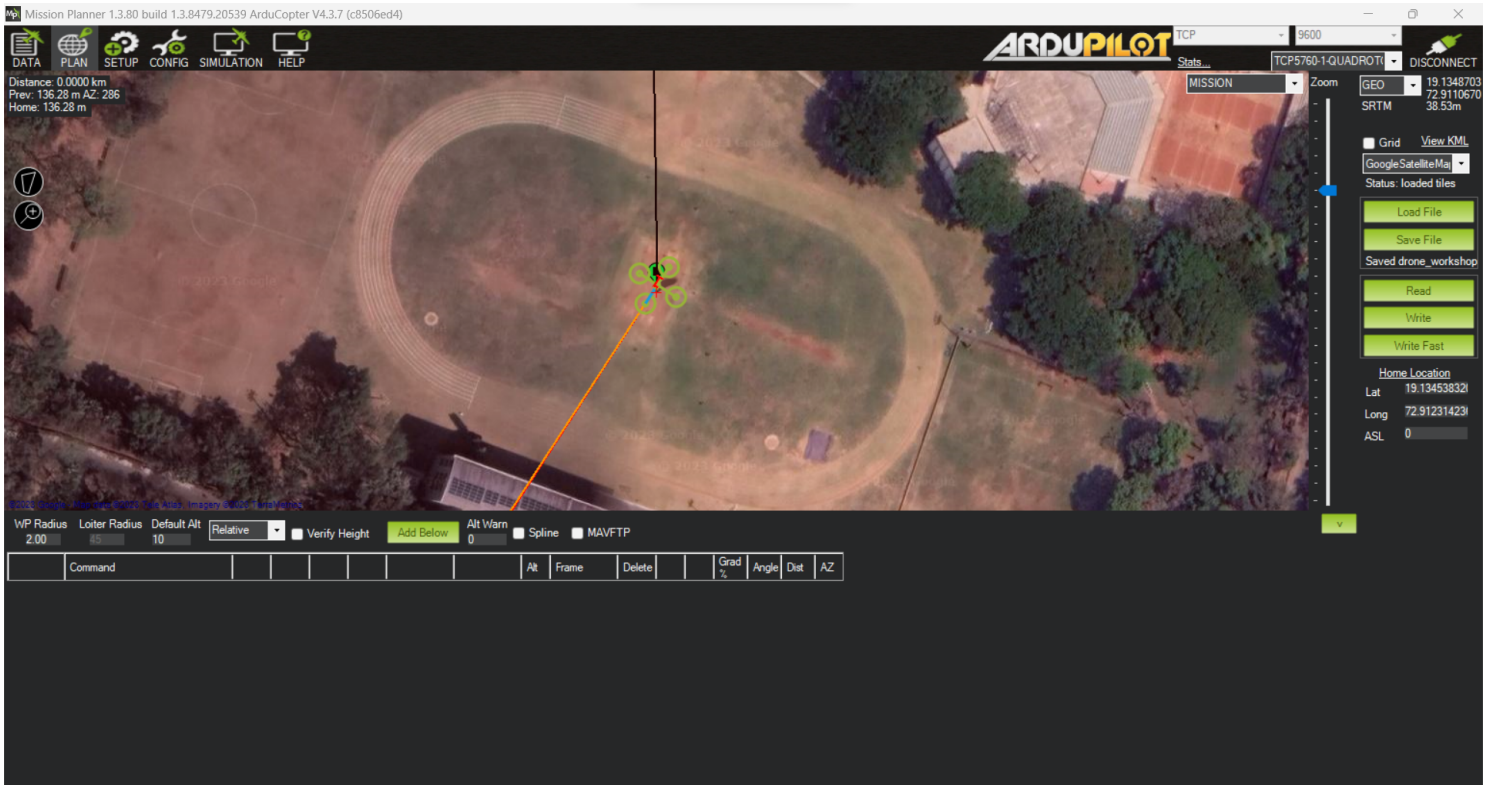
Mission Mode

Mission Planning

- Waypoint Definition
- Mission Parameters
- Pre-Flight Checks
- Mission Execution
- Monitoring and Safety
- Mission Completion

Mission Mode

- Waypoint Definition



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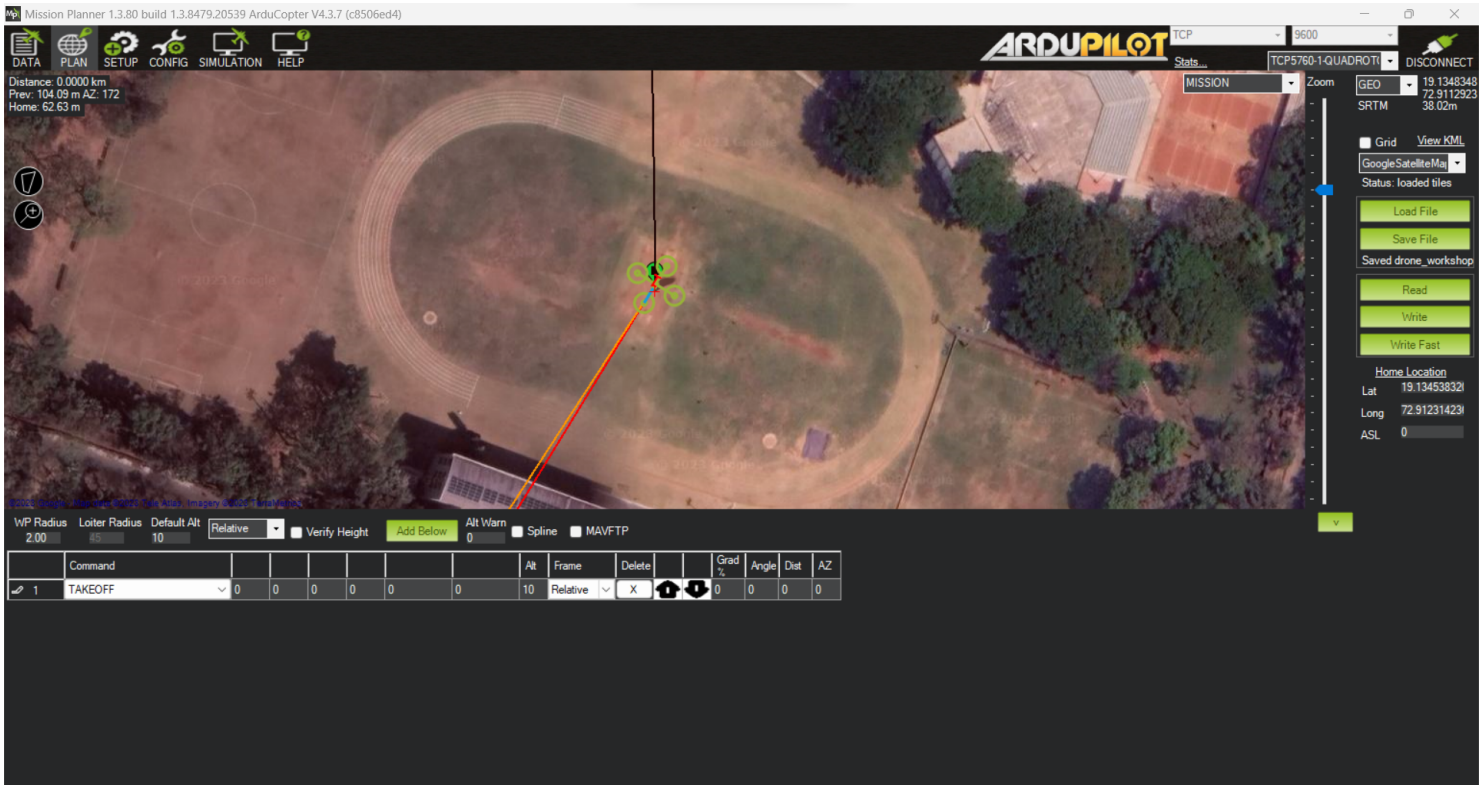

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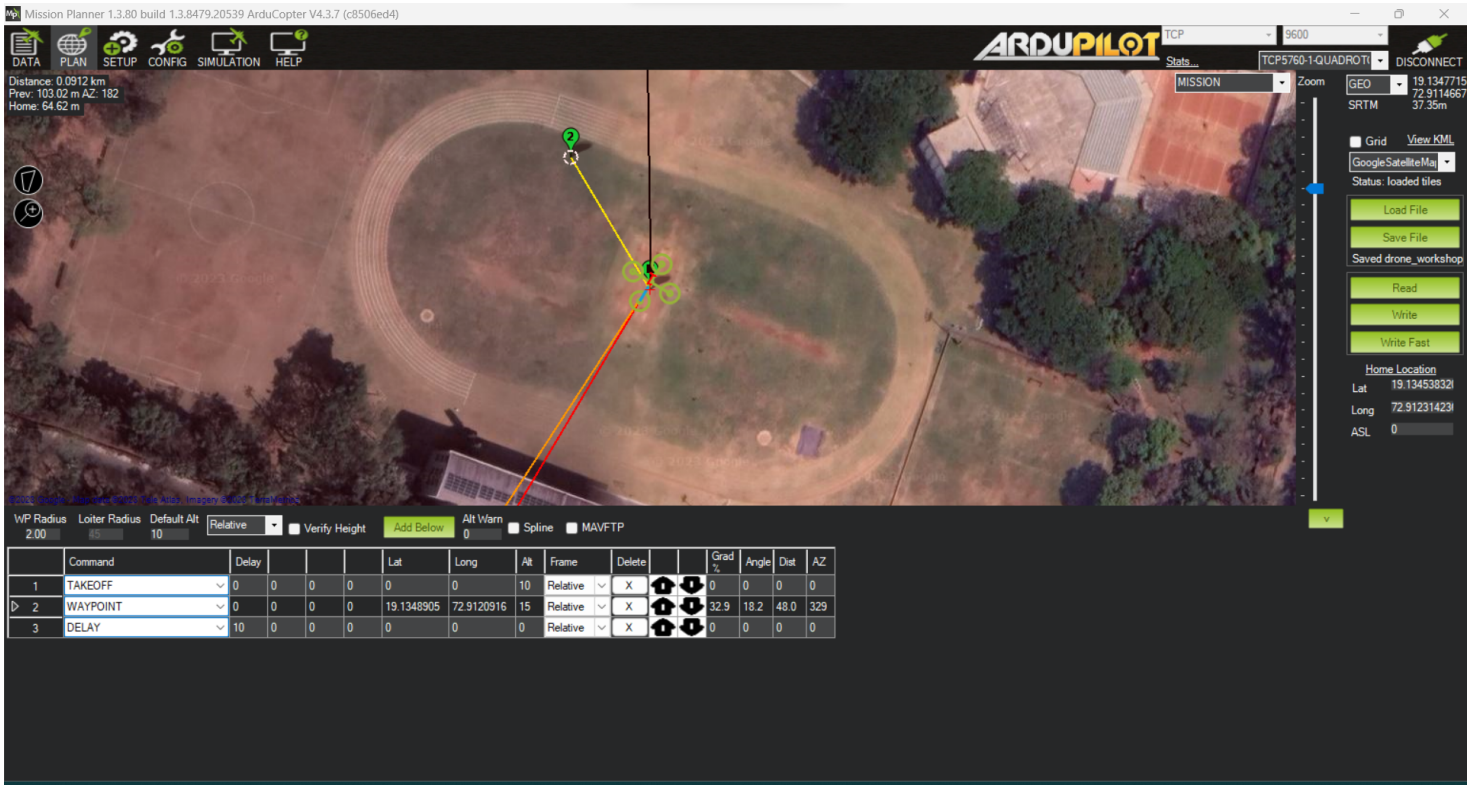

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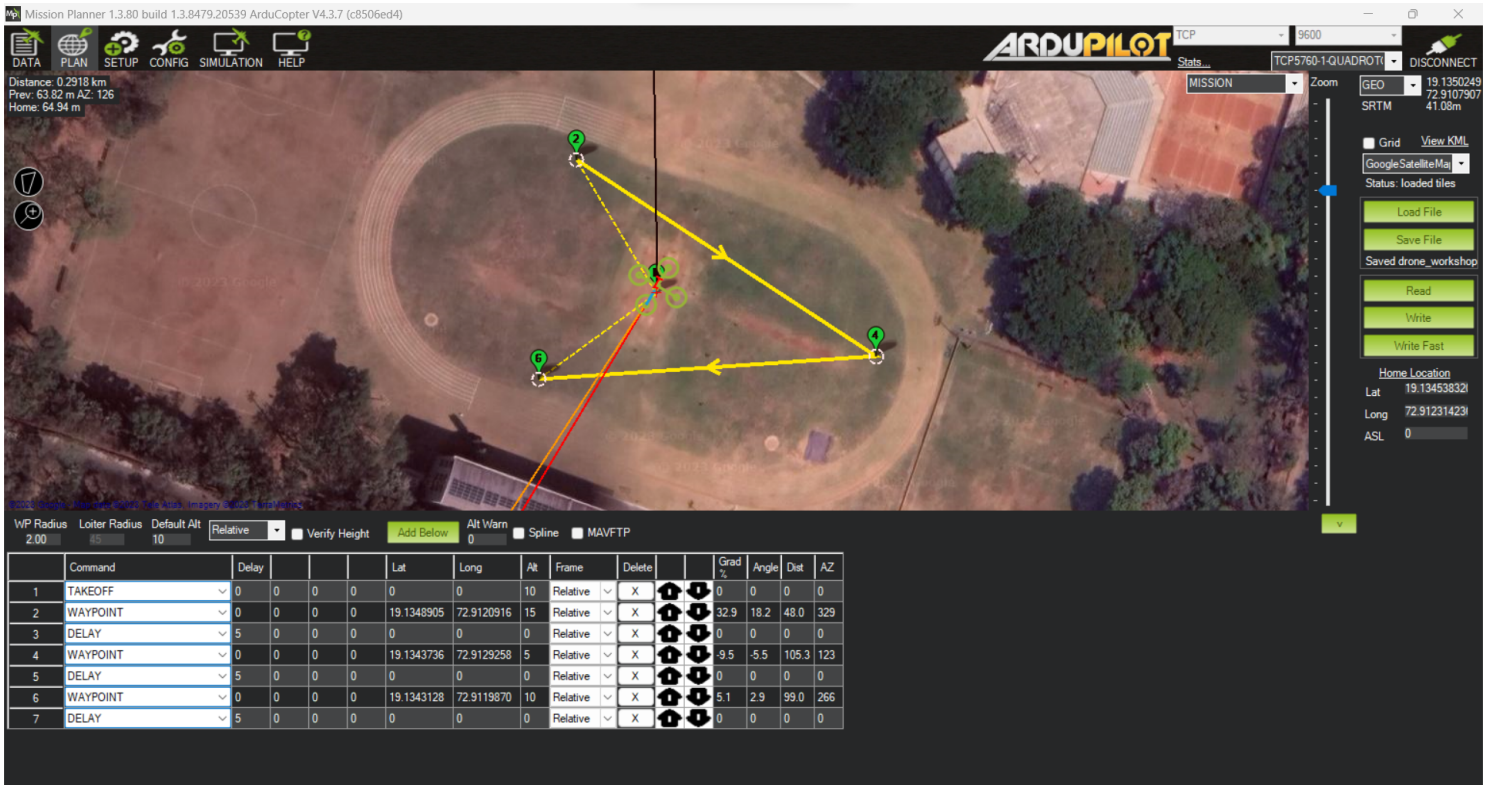

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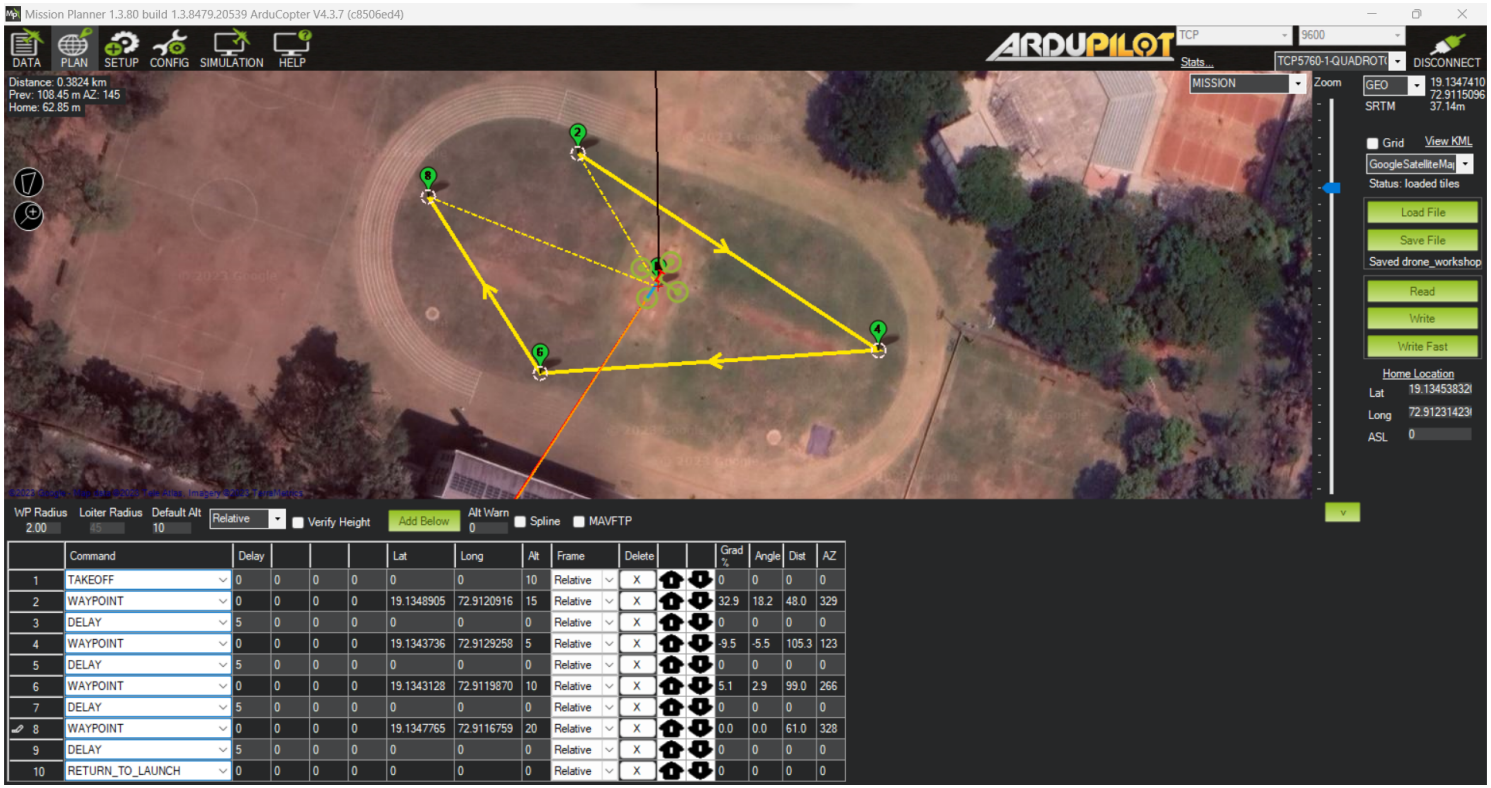
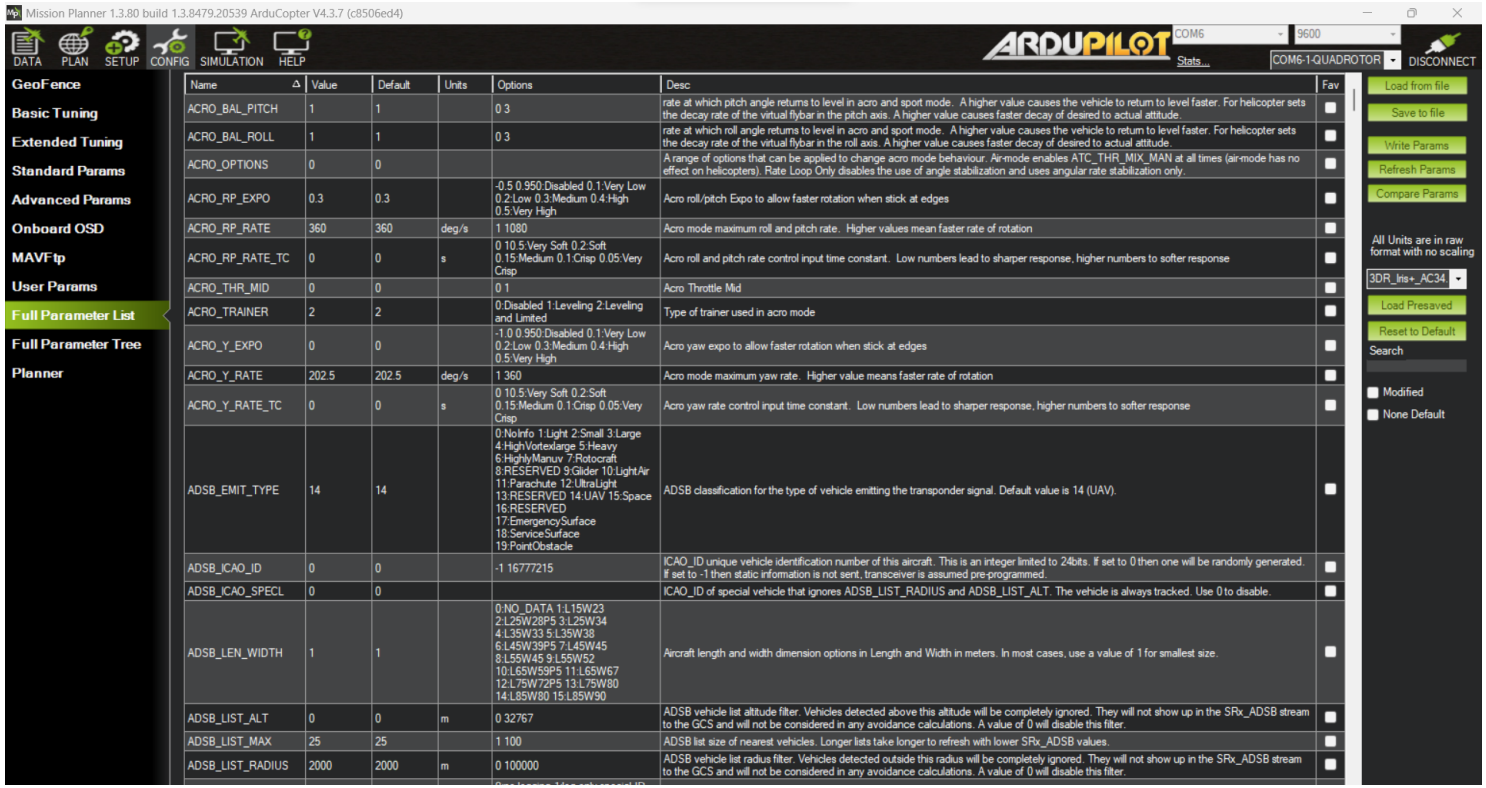


	Command	Delay				Lat	Long	Alt	Frame	Delete	Grad %	Angle	Dist	AZ
1	TAKEOFF	0	0	0	0	0	0	10	Relative	X	0	0	0	0
2	WAYPOINT	0	0	0	0	19.1348905	72.9120916	15	Relative	X	32.9	18.2	48.0	329
3	DELAY	5	0	0	0	0	0	0	Relative	X	0	0	0	0
4	WAYPOINT	0	0	0	0	19.1343736	72.9129258	5	Relative	X	-9.5	-5.5	105.3	123
5	DELAY	5	0	0	0	0	0	0	Relative	X	0	0	0	0
6	WAYPOINT	0	0	0	0	19.1343128	72.9119870	10	Relative	X	5.1	2.9	99.0	266
7	DELAY	5	0	0	0	0	0	0	Relative	X	0	0	0	0
8	WAYPOINT	0	0	0	0	19.1347765	72.9116759	20	Relative	X	0.0	0.0	61.0	328
9	DELAY	5	0	0	0	0	0	0	Relative	X	0	0	0	0
10	RETURN_TO_LAUNCH	0	0	0	0	0	0	0	Relative	X	0	0	0	0

Mission Mode

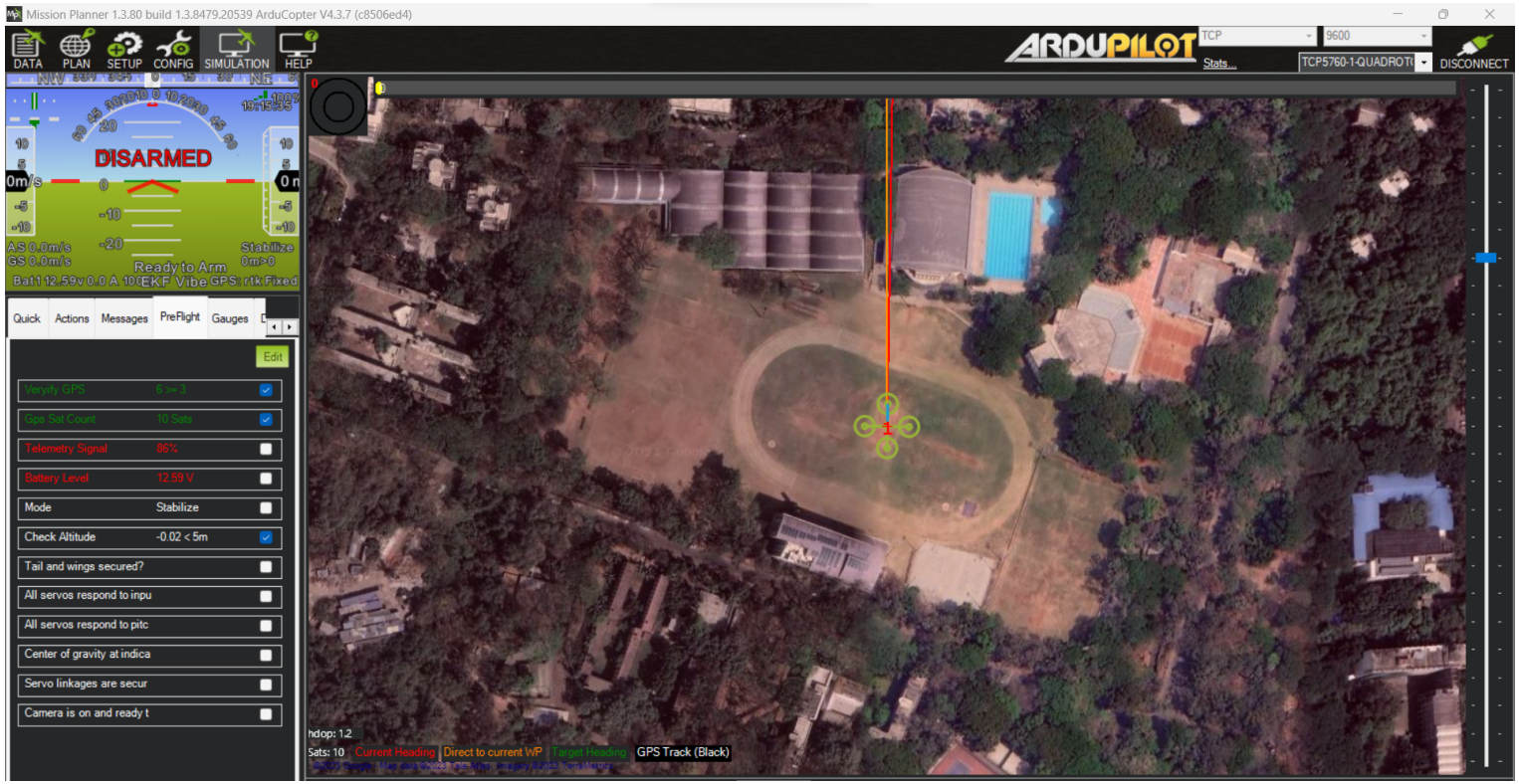
- Mission Parameters



Name	Value	Default	Units	Options	Desc	Fav
ACRO_BAL_PITCH	1	1		0 3	rate at which pitch angle returns to level in acro and sport mode. A higher value causes the vehicle to return to level faster. For helicopter sets the decay rate of the virtual flybar in the pitch axis. A higher value causes faster decay of desired to actual attitude.	
ACRO_BAL_ROLL	1	1		0 3	rate at which roll angle returns to level in acro and sport mode. A higher value causes the vehicle to return to level faster. For helicopter sets the decay rate of the virtual flybar in the roll axis. A higher value causes faster decay of desired to actual attitude.	
ACRO_OPTIONS	0	0			A range of options that can be applied to change acro mode behaviour. Air-mode enables ATC_THR_MIX_MAN at all times (air-mode has no effect on helicopters). Rate Loop Only disables the use of angle stabilization and uses angular rate stabilization only.	
ACRO_RP_EXPO	0.3	0.3		-0.5 0.95:0:Disabled 0.1:Very Low 0.2:Low 0.3:Medium 0.4:High 0.5:Very High	Acro roll/pitch Expo to allow faster rotation when stick at edges	
ACRO_RP_RATE	360	360	deg/s	1 1080	Acro mode maximum roll and pitch rate. Higher values mean faster rate of rotation	
ACRO_RP_RATE_TC	0	0	s	0 10.5:Very Soft 0.2:Soft 0.15:Medium 0.1:Crisp 0.05:Very Crisp	Acro roll and pitch rate control input time constant. Low numbers lead to sharper response, higher numbers to softer response	
ACRO_THR_MID	0	0		0 1	Acro Throttle Mid	
ACRO_TRAINER	2	2		0:Disabled 1:Leveling 2:Leveling and Limited	Type of trainer used in acro mode	
ACRO_Y_EXPO	0	0		-1.0 0.95:0:Disabled 0.1:Very Low 0.2:Low 0.3:Medium 0.4:High 0.5:Very High	Acro yaw expo to allow faster rotation when stick at edges	
ACRO_Y_RATE	202.5	202.5	deg/s	1 360	Acro mode maximum yaw rate. Higher value means faster rate of rotation	
ACRO_Y_RATE_TC	0	0	s	0 10.5:Very Soft 0.2:Soft 0.15:Medium 0.1:Crisp 0.05:Very Crisp	Acro yaw rate control input time constant. Low numbers lead to sharper response, higher numbers to softer response	
ADSB_EMIT_TYPE	14	14		0:NoInfo 1:Light 2:Small 3:Large 4:HighVortexlarge 5:Heavy 6:HighlyManuv 7:Rotocraft 8:RESERVED 9:Glider 10:LightAir 11:Parachute 12:UltraLight 13:RESERVED 14:UAV 15:Space 16:RESERVED 17:EmergencySurface 18:ServiceSurface 19:PointObstacle	ADSB classification for the type of vehicle emitting the transponder signal. Default value is 14 (UAV).	
ADSB_ICAO_ID	0	0		-1 16777215	ICAO_ID unique vehicle identification number of this aircraft. This is an integer limited to 24bits. If set to 0 then one will be randomly generated. If set to -1 then static information is not sent, transceiver is assumed pre-programmed.	
ADSB_ICAO_SPECL	0	0			ICAO_ID of special vehicle that ignores ADSB_LIST_RADIUS and ADSB_LIST_ALT. The vehicle is always tracked. Use 0 to disable.	
ADSB_LEN_WIDTH	1	1		0:NO_DATA 1:L15W23 2:L25W28P5 3:L25W34 4:L35W33 5:L35W38 6:L45W39P5 7:L45W45 8:L55W45 9:L55W52 10:L65W59P5 11:L65W67 12:L75W72P5 13:L75W80 14:L85W80 15:L85W90	Aircraft length and width dimension options in Length and Width in meters. In most cases, use a value of 1 for smallest size.	
ADSB_LIST_ALT	0	0	m	0 32767	ADSB vehicle list altitude filter. Vehicles detected above this altitude will be completely ignored. They will not show up in the SRx_ADSB stream to the GCS and will not be considered in any avoidance calculations. A value of 0 will disable this filter.	
ADSB_LIST_MAX	25	25		1 100	ADSB list size of nearest vehicles. Longer lists take longer to refresh with lower SRx_ADSB values.	
ADSB_LIST_RADIUS	2000	2000	m	0 100000	ADSB vehicle list radius filter. Vehicles detected outside this radius will be completely ignored. They will not show up in the SRx_ADSB stream to the GCS and will not be considered in any avoidance calculations. A value of 0 will disable this filter.	

Mission Mode

- Pre-Flight Check



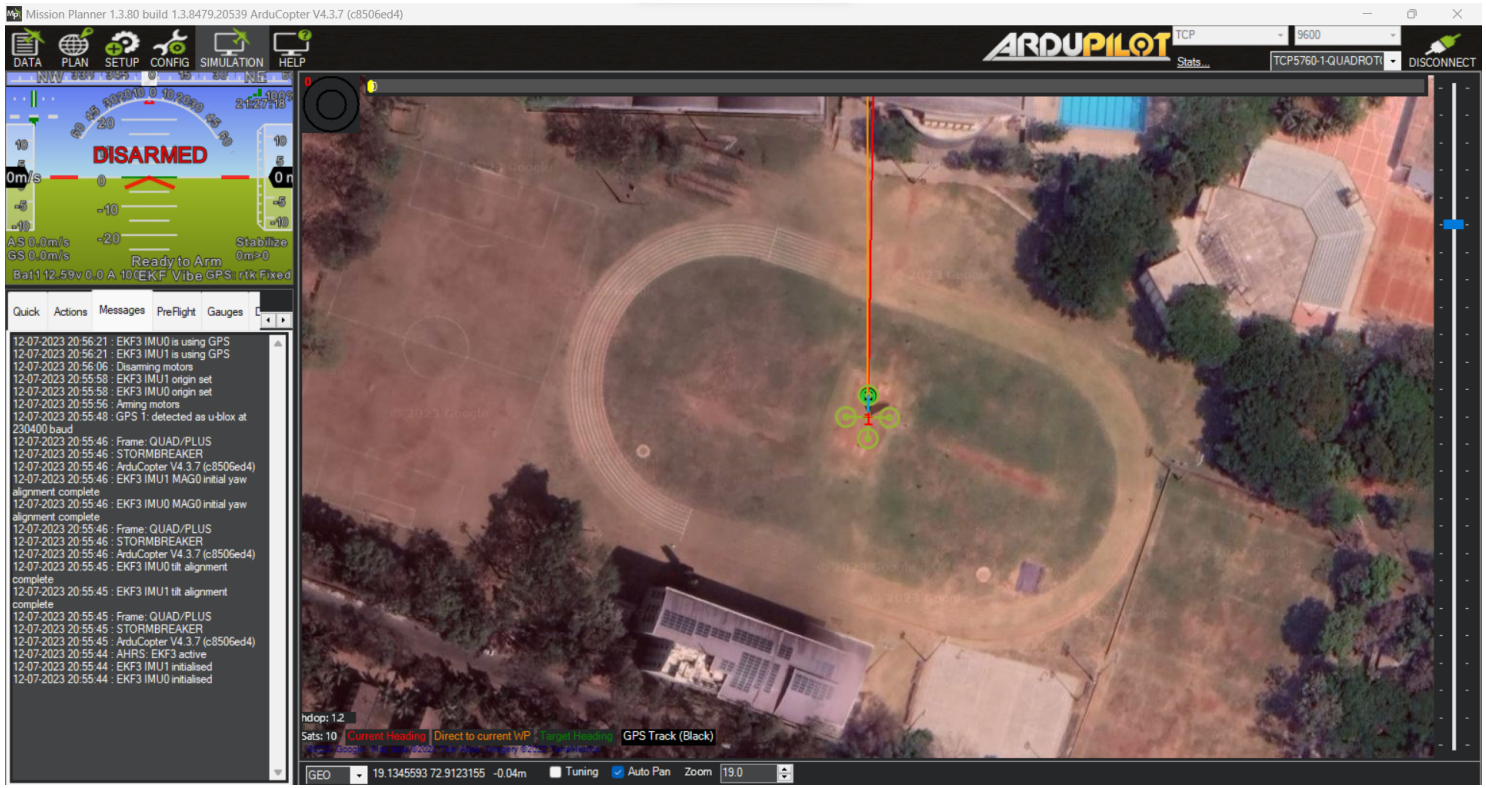
Mission Mode

- Mission Execution

Video

Mission Mode

- Monitoring and Safety



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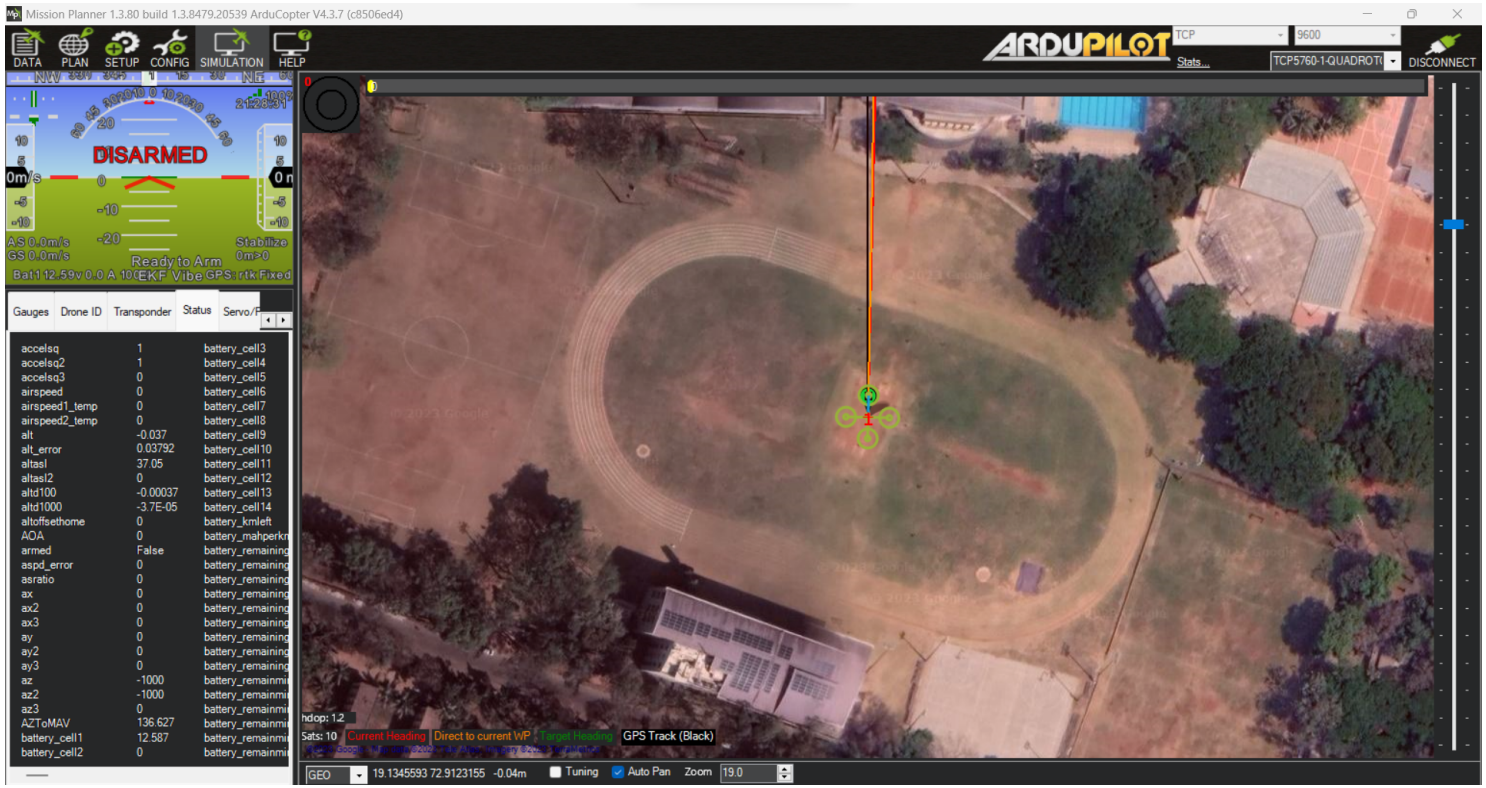
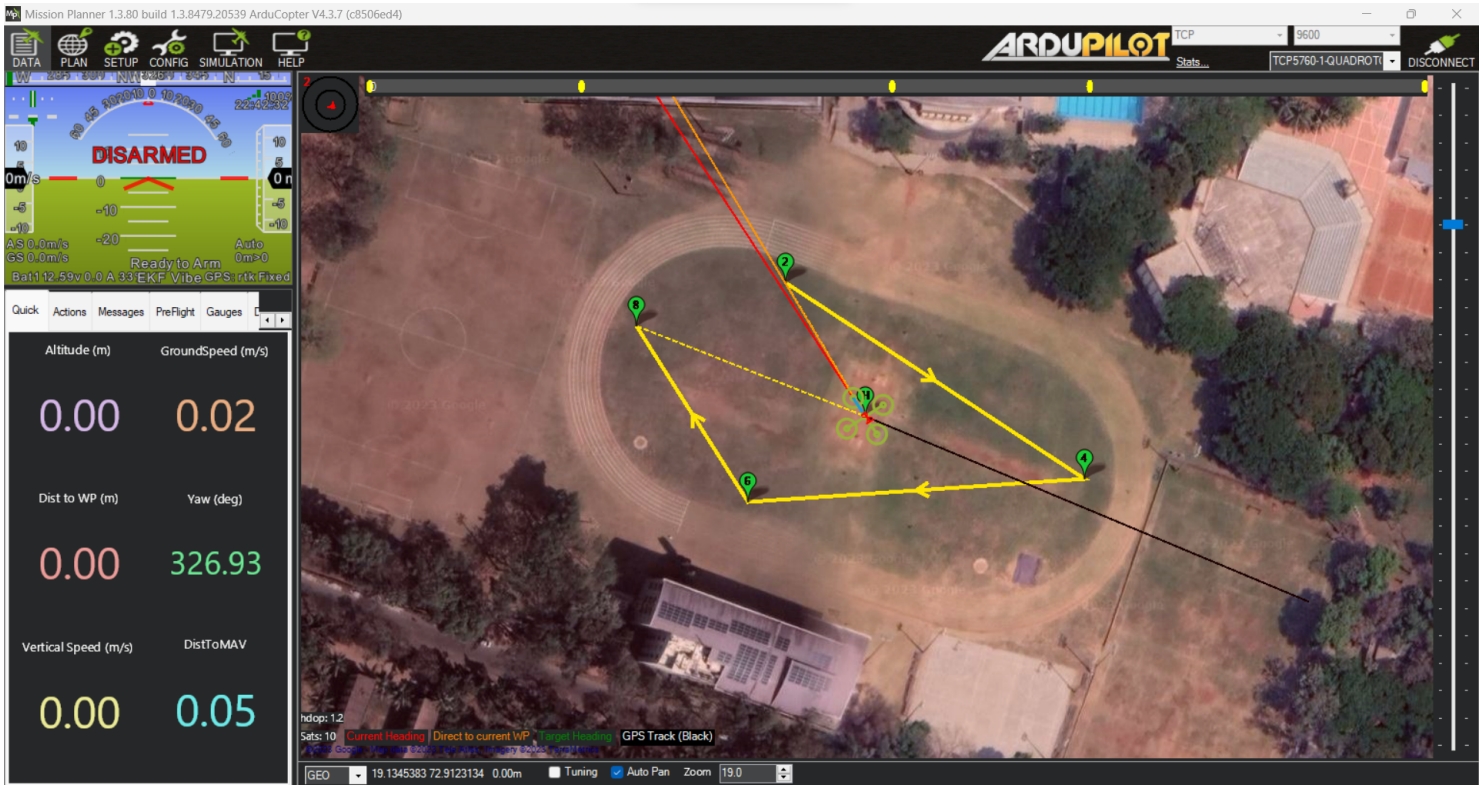


Mission Mode

- Mission Completion



Offboard Mode

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- These setpoints are provided by an external source such as a companion computer
- This mode requires position or pose/attitude information

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- Uses The setpoints may be provided using MAVLink or by ROS/ROS2 commands

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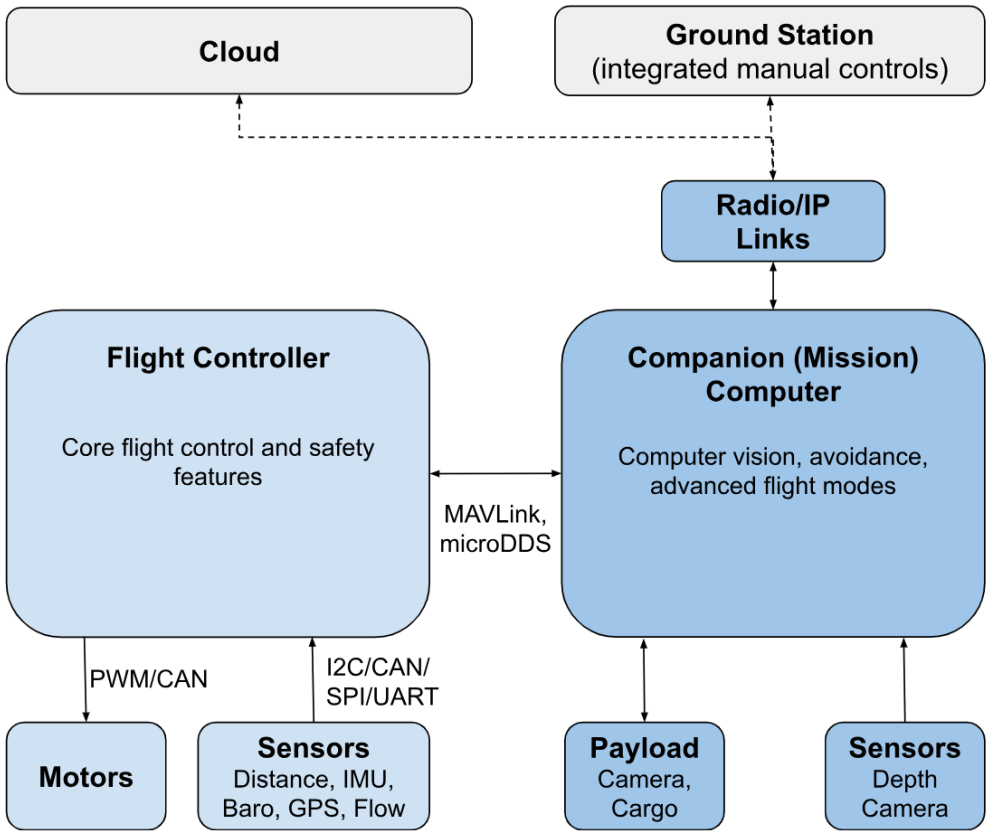
- RC control is disabled except to change modes
- This mode is used for controlling vehicle movement and attitude
- Used in research, development, and advanced applications

Offboard Mode



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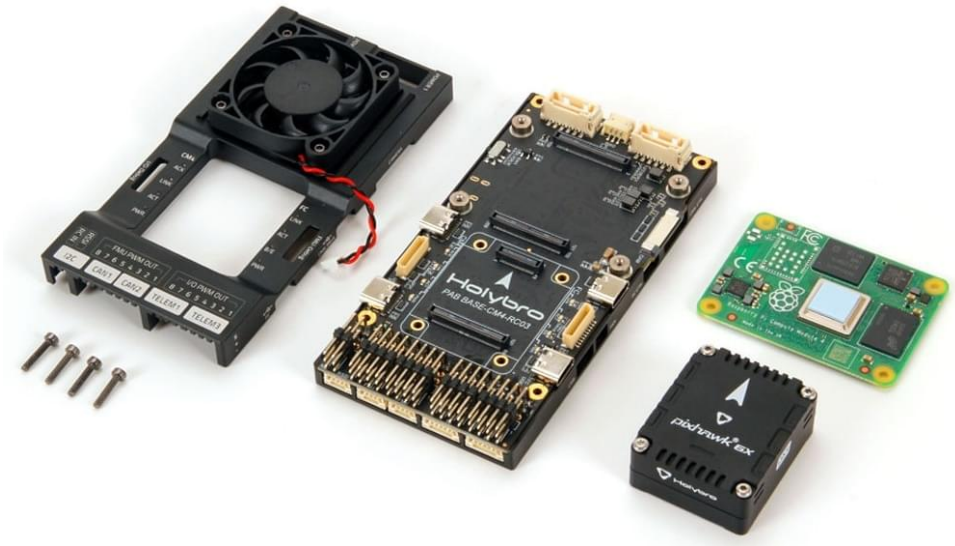

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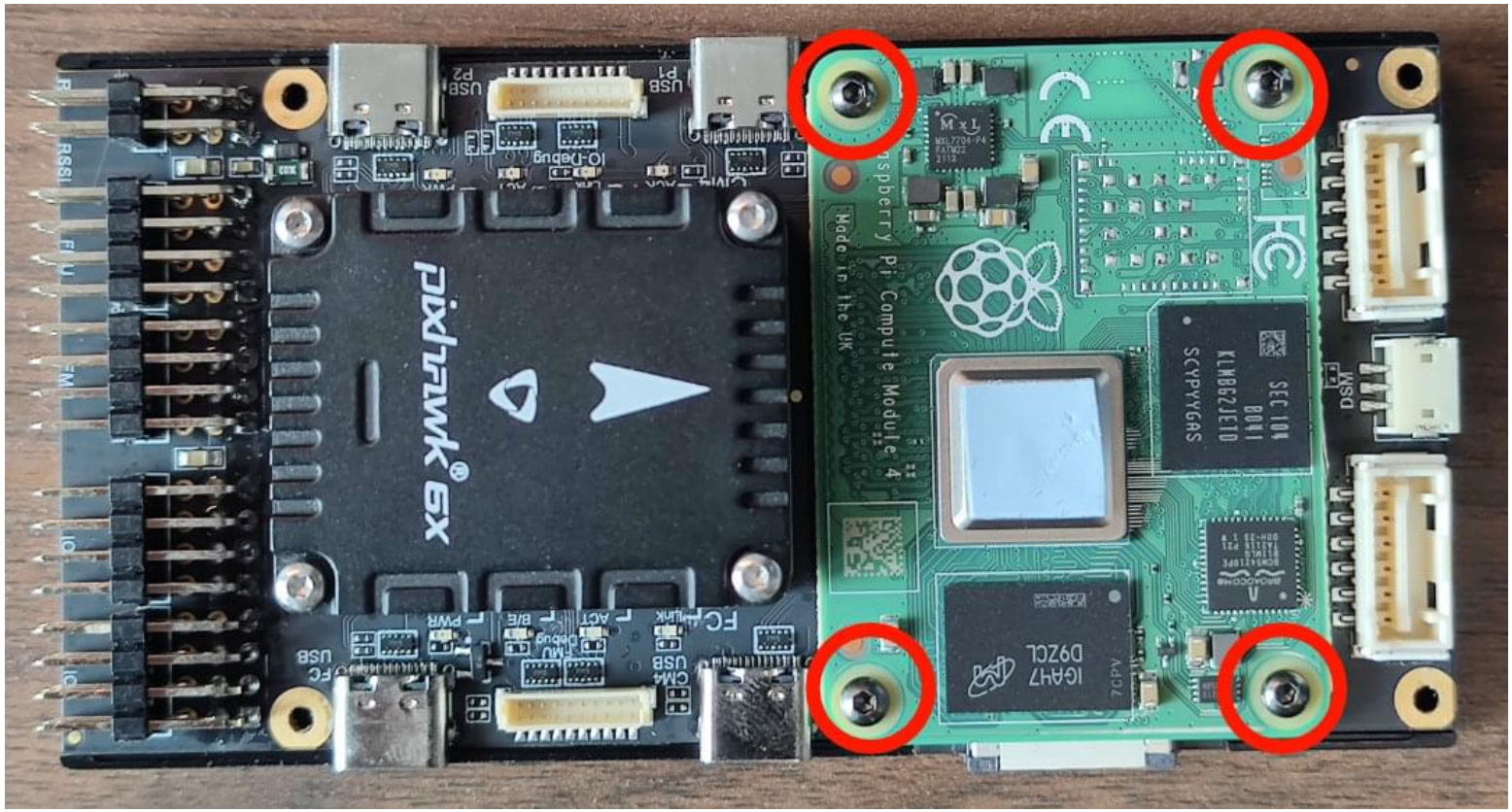


Offboard Mode

Video

Intelligent Autopilot Stacks

1. SLAM
2. 3DVFH

SLAM

Simultaneous Localization and Mapping

- Mapping

SLAM

Simultaneous Localization and Mapping

- Mapping
- Localization

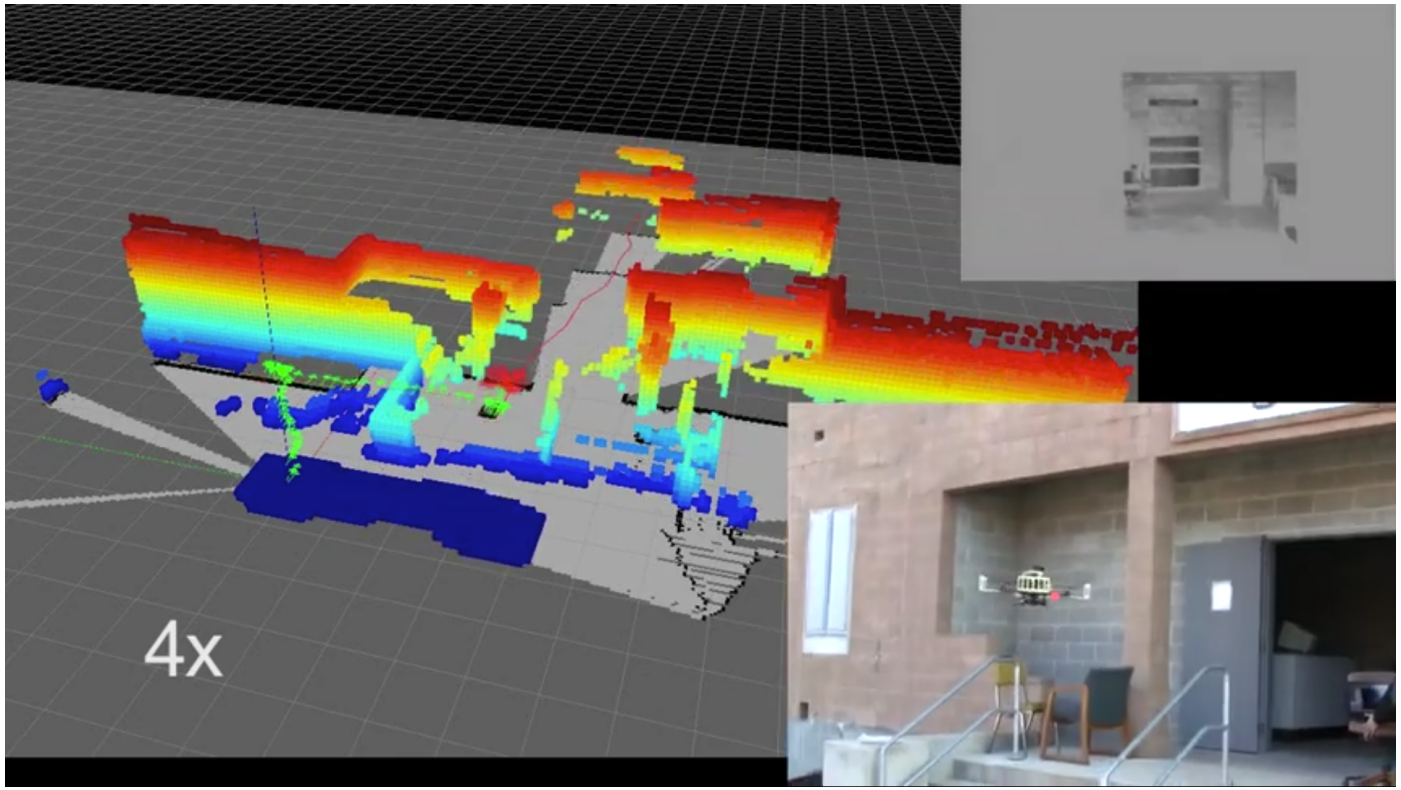
SLAM

Simultaneous Localization and Mapping

- Mapping
- Localization
- Odometry and Sensor Fusion

SLAM

SLAM



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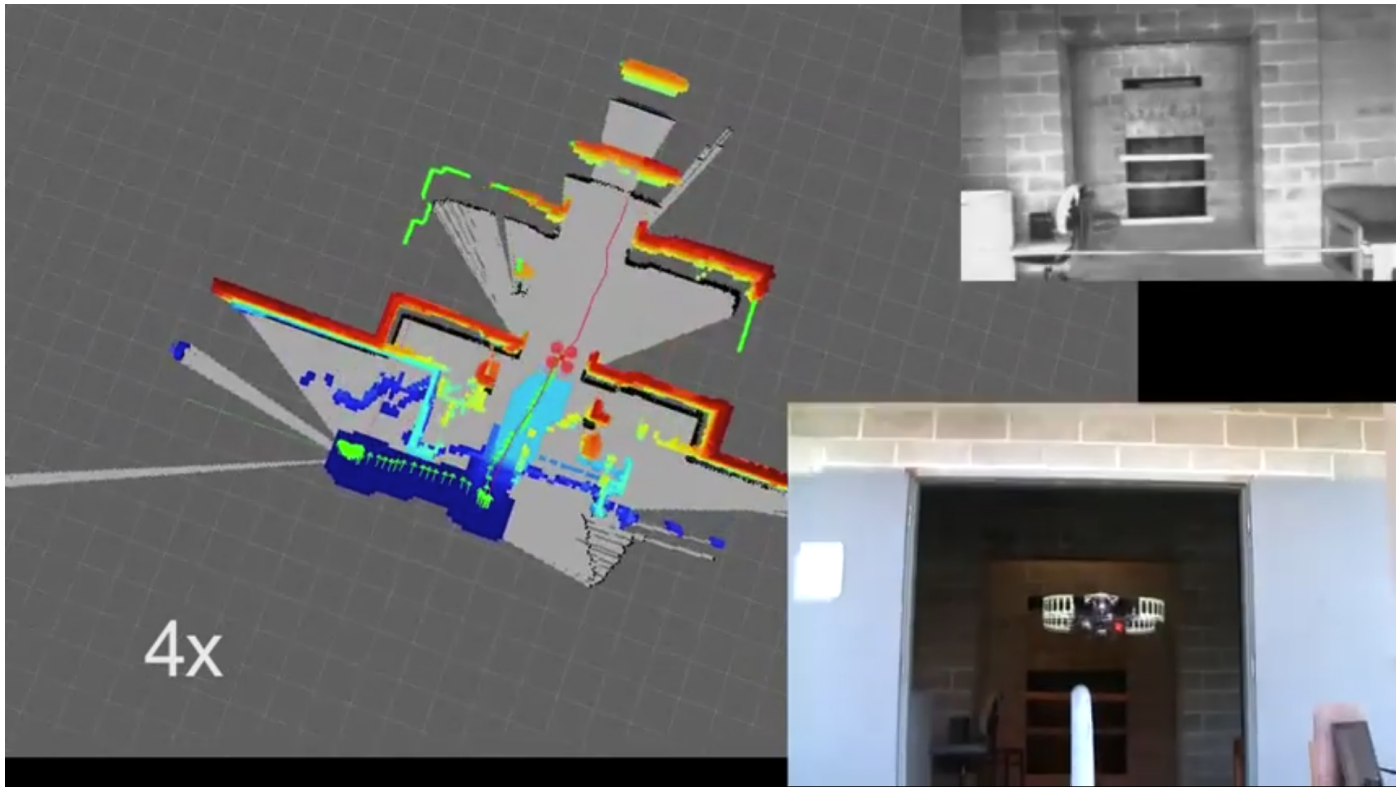

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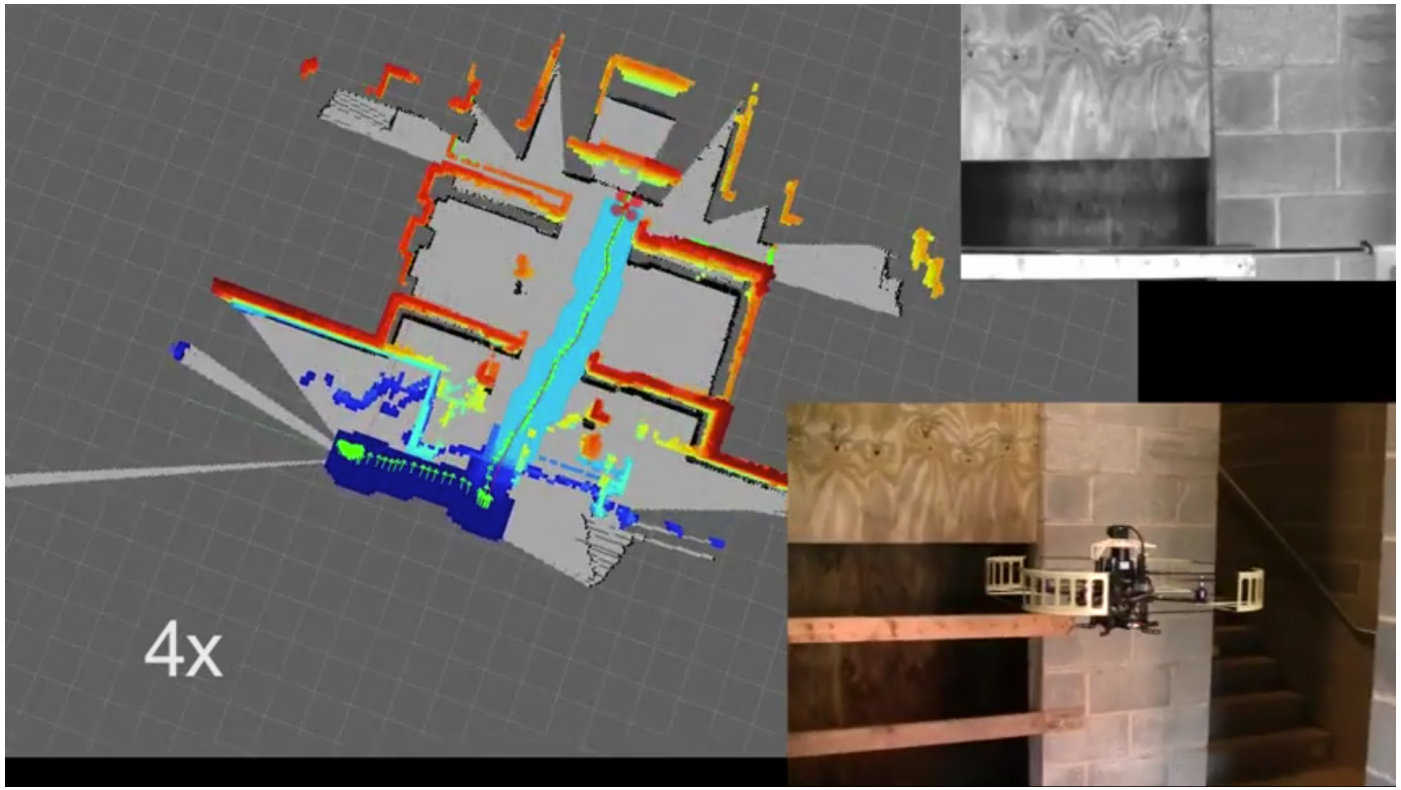
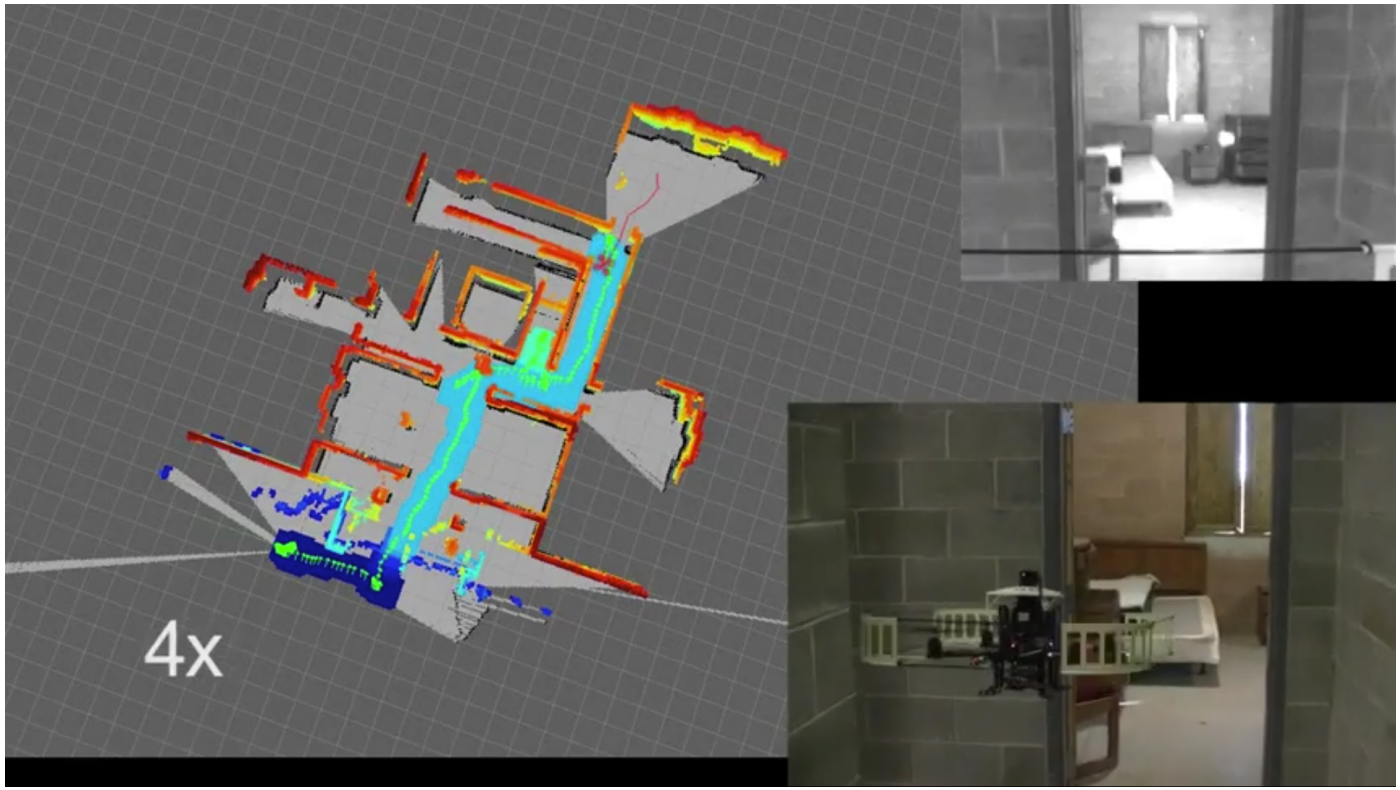


SLAM



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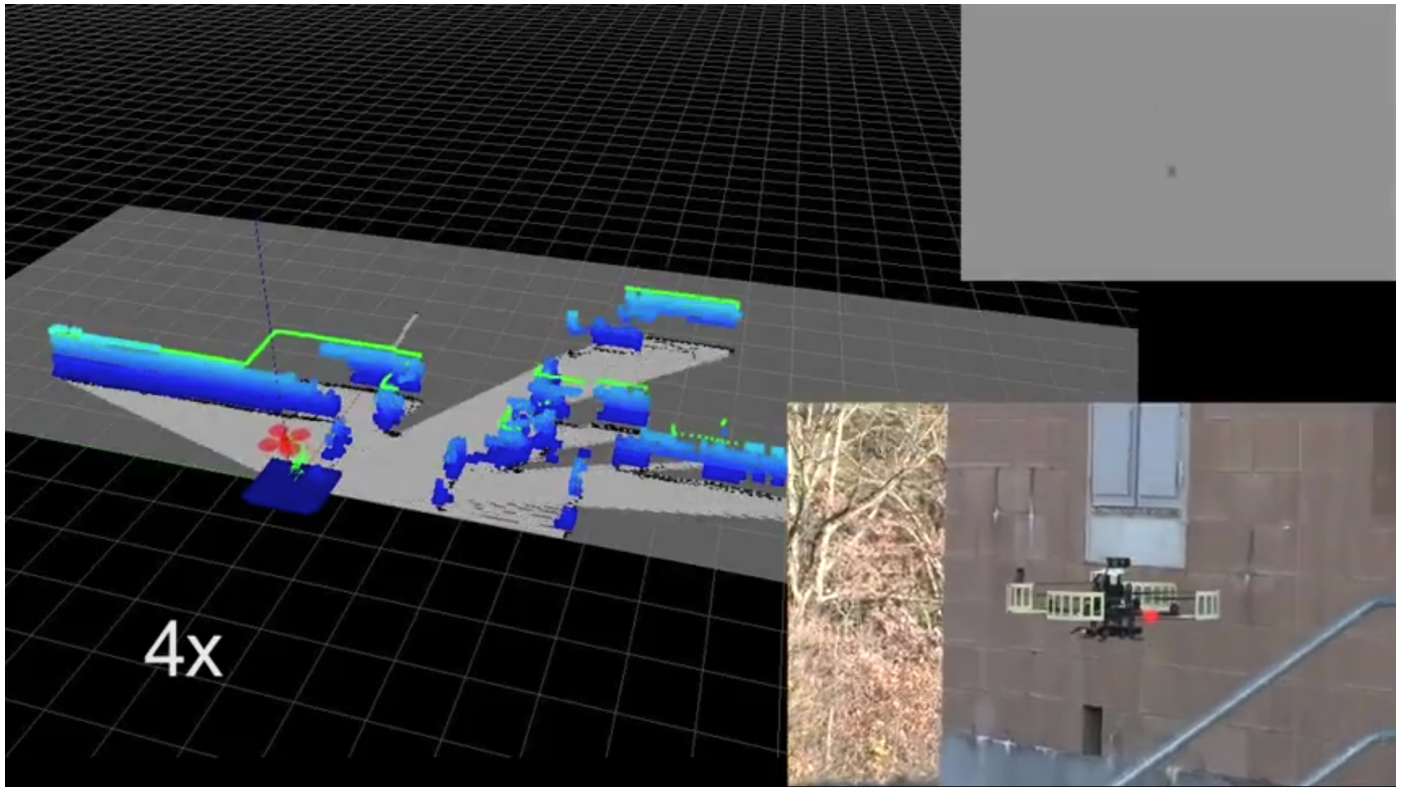

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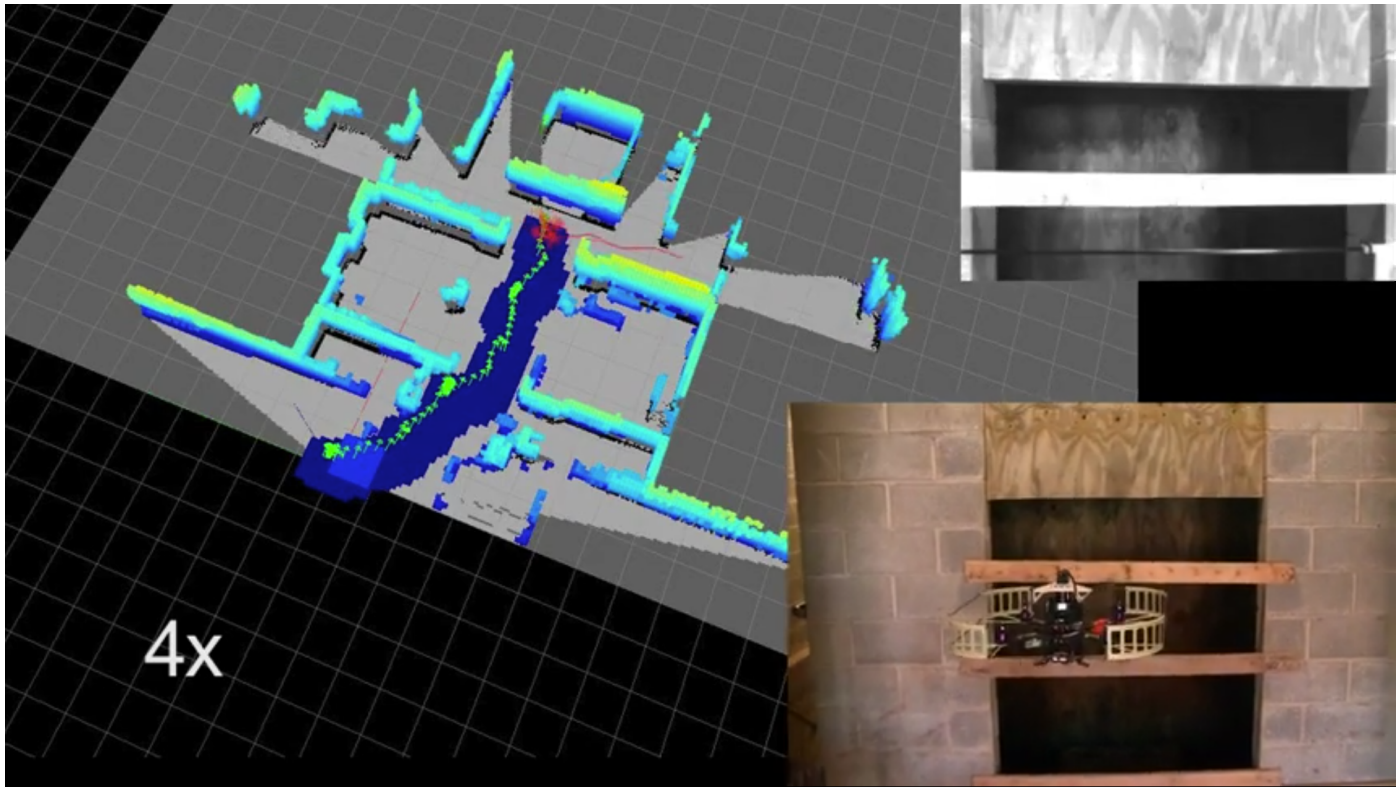

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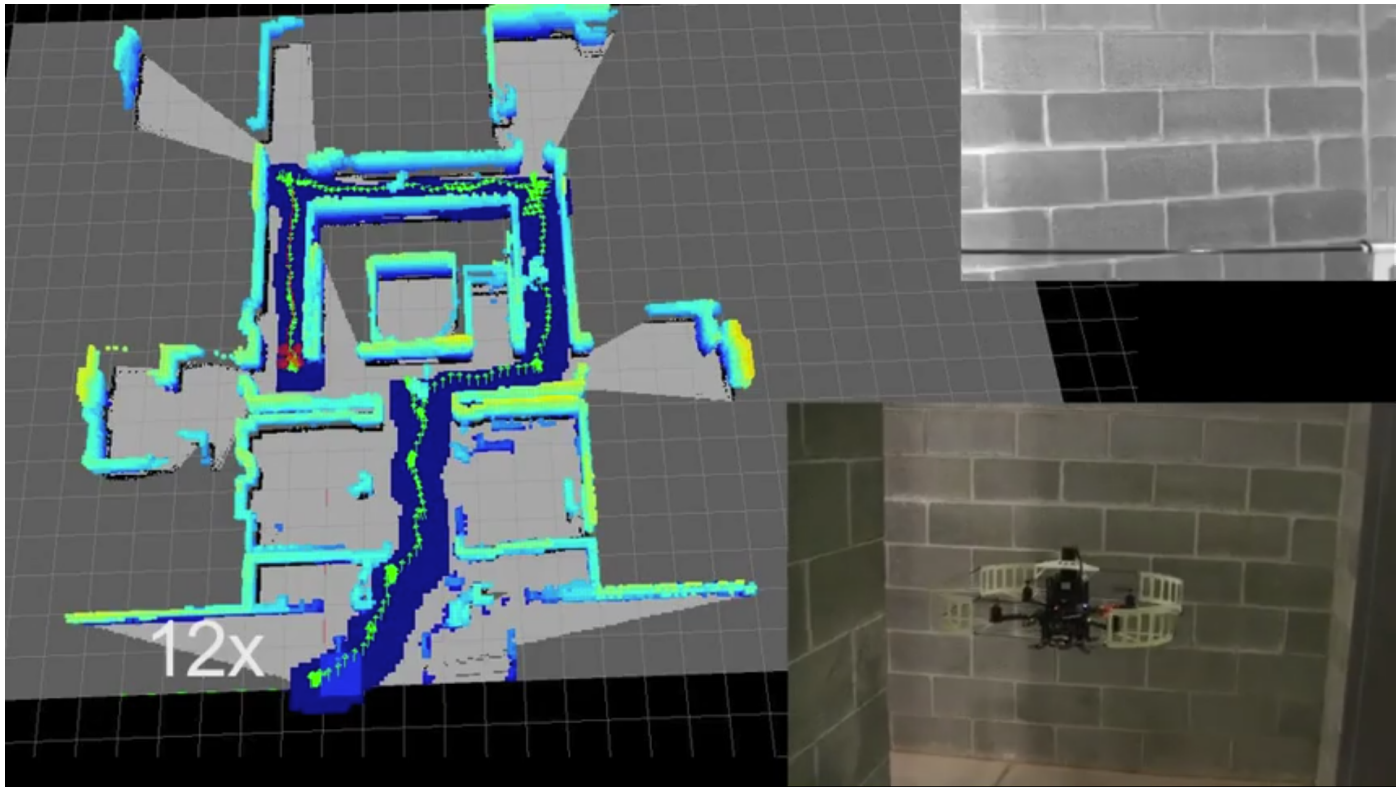

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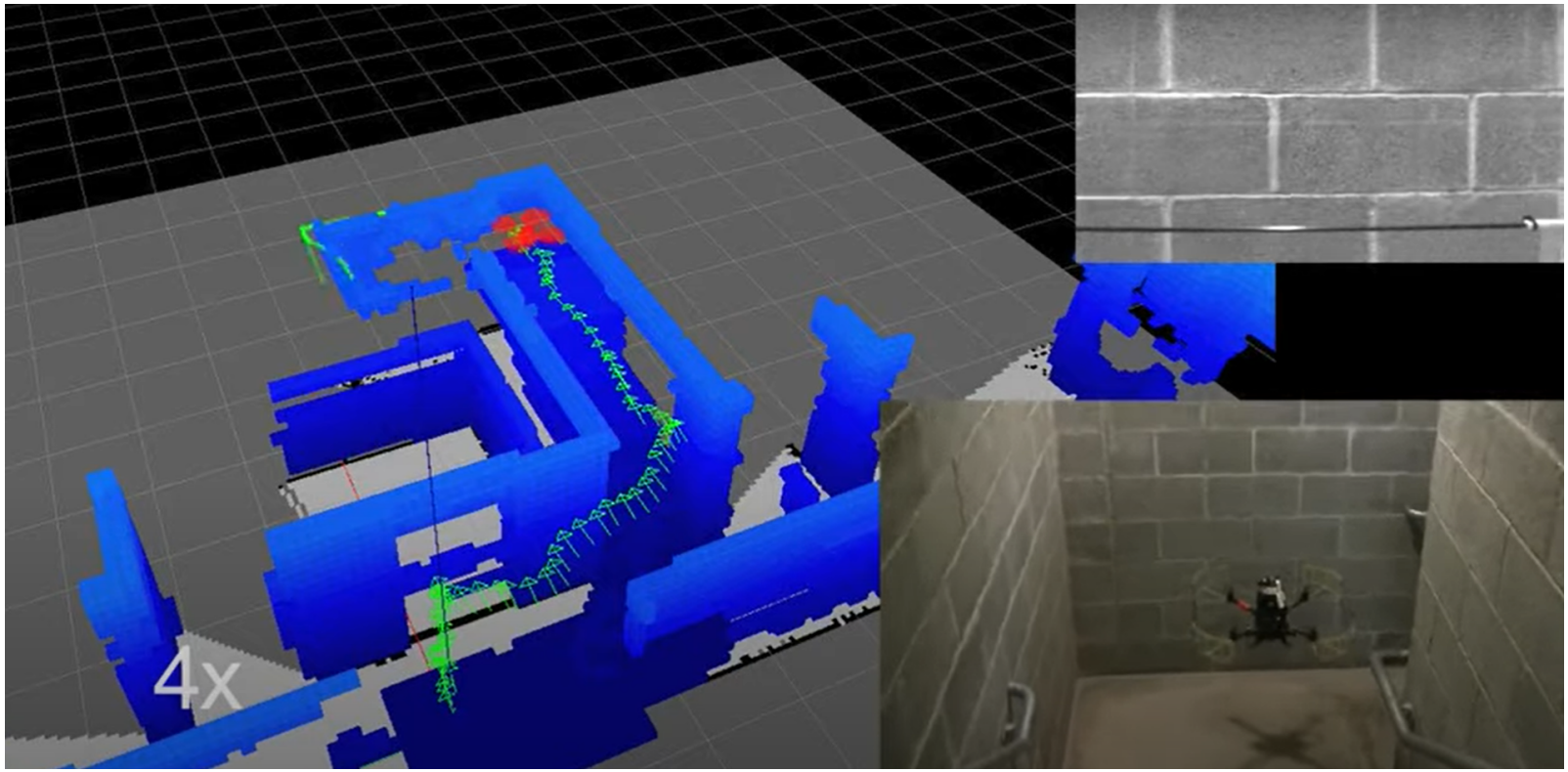

SLAM

Video

3DVFH

Three-Dimensional Vector Field Histogram

- A feature descriptor used in robotics and autonomous navigation

3DVFH

Three-Dimensional Vector Field Histogram

- A feature descriptor used in robotics and autonomous navigation
- Used to analyze and classify the environment around a robot or drone

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- A feature descriptor used in robotics and autonomous navigation
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Three-Dimensional Vector Field Histogram

- A feature descriptor used in robotics and autonomous navigation
- Used to analyze and classify the environment around a robot or drone
- Obstacle detection and avoidance
- Object recognition and tracking
- Environmental mapping

3DVFH

Video

Sample Configuration

1. Frame - Tarot Iron Man 650

Sample Configuration

1. Frame - Tarot Iron Man 650
2. Propellers - T-Motors CFProp 15x5R

Sample Configuration

1. Frame - Tarot Iron Man 650
2. Propellers - T-Motors CFProp 15x5R
3. Motors - T-Motor MN4010-14 KV370

Sample Configuration

1. Frame - Tarot Iron Man 650
2. Propellers - T-Motors CFProp 15x5R
3. Motors - T-Motor MN4010-14 KV370
4. ESC - T-Motor F55A Pro II 55A 3-6s BLHeli32 4-in-1 ESC with BEC

Sample Configuration

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2. Propellers - T-Motors CFProp 15x5R
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7. Remote controller - FrSky Taranis X9D Plus

Sample Configuration

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6. GNSS - Holybro H-RTK F9P
7. Remote controller - FrSky Taranis X9D Plus
8. Receiver - FrSky Archer R8 PRO

Sample Configuration

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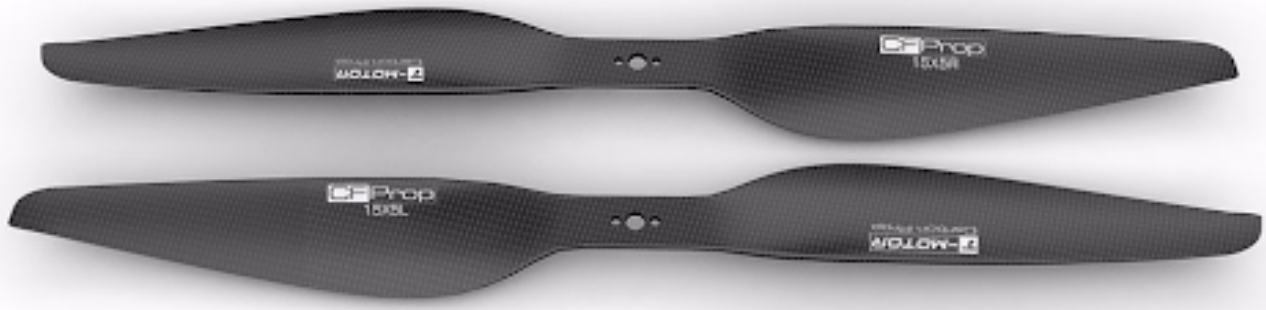
3. Motors - T-Motor MN4010-14 KV370
4. ESC - T-Motor F55A Pro II 55A 3-6s BLHeli32 4-in-1 ESC with BEC
5. Flight controller - Cube Orange + with ADS-B carrier board
6. GNSS - Holybro H-RTK F9P
7. Remote controller - FrSky Taranis X9D Plus
8. Receiver - FrSky Archer R8 PRO
9. Battery - GenX Power Premium 22.2V 6S 10000mAH 25C LiPo Battery

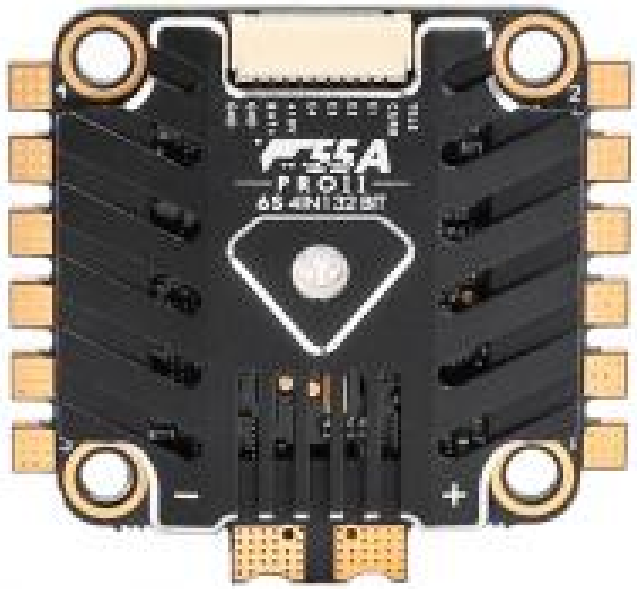
Tarot Iron Man 650

T-Motors CFProp 15x5R



T-Motor MN4010-14 KV370

T-Motor F55A Pro II 55A 3-6s BLHeli32 4-in-1 ESC with BEC0



Cube Orange + with ADS-B carrier board

Holybro H-RTK F9P

FrSky Taranis X9D Plus

FrSky Archer R8 PRO

GenX Power Premium 22.2V 6S 10000mAH 25C LiPo Battery

Thank You!