Introduction:

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Specialization high power electronics for Electric Vehicle

BMW EA-440 Electric Vehicle powertrain electronics pre-development

1st RC Cars with BaHa Bug 1984, some mixed success with fixed wing models late 80s and multi-rotors today.

Microlight flying 1997-99 with Pegasus XL

Mixed models for RC flying including fixed wing and multi rotor

About the topic:

FPV Modeling

What is FPV

First person view.

Original 'PC Nerds/Gamers' will know FPV from the PC game world where player sees the character perspective and moves through a virtual world (mostly trying to destroy most of what is found, for me anyway).

Nerd transformation

In the model world mainstream FPV is now an affordable way to get a pilots view and add a dimension to the model flying experience.

For FPV the key criteria are the immersion experience taking the 'pilot' to the cockpit.

A look into moving from computer screen virtual reality to immersive reality combined with model flying. Some information on the tech bit and a collection of short video clips.

Why FPV

2 main paths, photographer or videographer and pure immersive flying.

Photographer typical platform is multi-rotor and stabilized camera platform. Platform sized for camera payload.

Immersive flying with fixed wing or multi-rotor and high speed video link.

Short clip from Sharpo

Multirotor platform

Multi rotors come in many configurations, tricopter for high speed dynamic operation. Similar flight characteristic to fixed wing with ability to hover. Simple low cost build, complex rear rotor due to thrust vector on rear axis.

Quad is common due to simple mechanical assembly and minimum configuration for non thrust vectoring. Hobby quads in many sizes, size defined as center distance from opposing prop centers and typical entry point for FPV is Hubsan X4, 60mm x 60mm with basic camera and transmitter with integrated screen. Race quad common size is 250 class and in general kit built. No real limit other than practicality on how big they can go. Hex can be Y or X configuration where Y gives wider camera view angle availability and X gives higher efficiency. Hex advantage is with appropriate control system has some redundancy. Octo for heavy lift and commercial video and camera work.

Conventional wing platform

New smaller cameras make FPV available across most models. Pusher options have advantage of not looking through the prop or wing mounting cameras.

Some very novel camera positioning has been experimented with and generally better for immersive high speed flying.

How to get started

Understand your path, photography/videos or immersive flying.

Mix is to add a 2nd camera to have both but typical dynamic platform will require a high speed video link for flying and small (GoPro/Mobius) recording camera.

For high quality capture recording is onboard and transmission from quality camera will have some latency.

1st entry typically fast link video for immersion flying.

Tech bit:

Types of system, frequencies pros cons and how they connect

Cameras, basic or recording or off-board recording

Board cameras with PAL/NTSC, 520/600/700 line.

Recording cameras typically 720/1080/1440 HD.

Viewing angle, 110° 148° or xxxx. Wide angle is used as can reduce effect of transmitted vibration, rolling shutter effect or jello effect. With high speed motors an unbalanced prop can cause poor video quality due to mixing with resonance of shutter speed. The effect is dissorientationg and good prop balance makes a big difference.

Danger of perspective, with wide angle distance seems greater. When flying low and fast watch ground speed, distances are exaggerated greatly and when flying over be sure to be clear.

The link, 900MHz, 1.2GHz, 2.4GHz, 5.8GHz

CH / FR		CH							
		CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8
FR	FR1 or（A）	5865M	5845M	5825M	5805M	5785M	5765M	5745M	5725M
	FR2 or（B）	5733M	5752M	5771M	5790M	5809M	5828M	5847M	5866M
	FR3 or（E）	5705M	5685M	5665M	5645M	5885M	5905M	5925M	5945M
	FR4 or（F）	5740M	5760M	5780M	5800M	5820M	5840M	5860M	5880M

Lower frequency for long range but select to be outside model transmitter range.

900MHz is good for several km but this has questionable use as a responsible pilot will not be flying out of line of sight without special permissions.

Europe regulation is 25mW for transmitter at 5.8GHz, typical commercial system. This is 200-500m but has no penetration power so won't pass trees or buildings. Still as out of line of sight not such an issue. For low level course flying in controlled space lower frequency or better antenna will be needed. US distributers carry 200mW, 600mW and 800mW transmitters. Not legal in Europe and risk of such high power transmitter is effectively jamming the control radio. Power is also not free and will impact flight times although not so great (600mW or 0.6W measured next to a quad pushing upto 800W of motor).

Receiver end, mini Screen and goggles.

FPV specific equipment typically integrated with 5.8GHz receivers (multi channel) but standalone available and typical for other frequencies.

Screen has advantage of easy to share experience but screen more immersive.

2 types of goggles, FatShark type with stereo screens close and deeply immersive, monitor headgear. Large cost delta fro <100 Euros to >300 Euros. Can incorporate head tracking in 2 axis for camera steering, typically on fixed wing type FPV flying.

Screen less immersive but easier to transition from line of sight takeoff to FPV and back. Typical cost is also much lower.

Receiver matched to transmitter, critical component is the antenna with Tx power so low the antenna has more impact than more power in transmitter. Equipment is traditionally shipped with linear antenna (black stick type) that have very low gain and work well on the bench only.

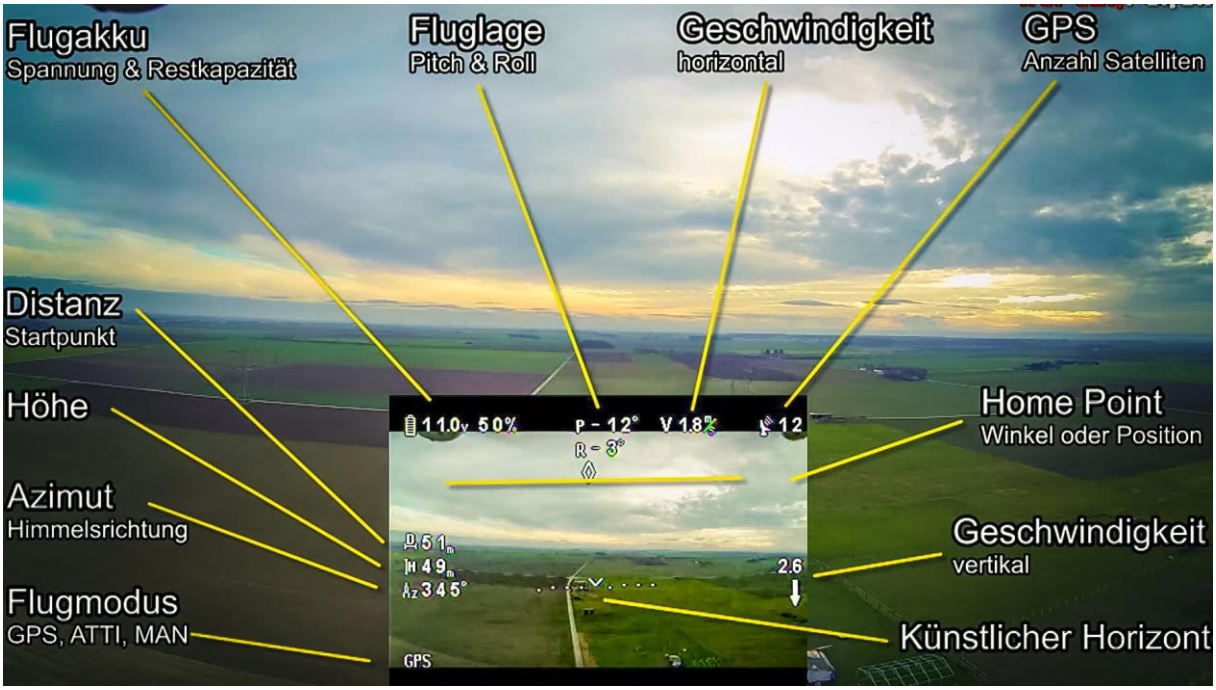
For such low power circular polarized, directional or even tacking antenna have the highest benefit.

Next project tracking antenna with high gain!

Telemitary, why and what to add.

Telemetry gives an overlay of flight information from the craft. Simple voltage level is useful to determine when the battery is low and the flight time is finished.

Additional information is available coupled with high levels of instrumentation. Typical DJI integrated system can provide sensor feedback for horizontal speed, VSI, GPS position and home point tracker, voltages horizon, signal strength and operation mode.



What does it cost

How long is a string of elastic?

Hubsan X4 quad with camera and control, built in monitor from 130 Euros.

Full DJI Inspire with HD camera 3600 Euros.

Between are many configurations depending on the job and expectation of camera output.

Typical racing 250 quad and control 200-400 Euros with video system from 100 Euros to 1000 Euros.

For photography a more complex craft with advanced control typical build cost <1000 Euro with a good camera.

Additional cameras and transmitters as low as 30 Euros so additional model FPV is not so difficult.

Flying wing cost around 100 Euro for wing and Tx with basic 30 Euro video system.

Camera, Tx, Rx, vision system,

Recording, Telemitary automation

How safe is it?

As same as modelflying, easier to control as no loss of orientation but easy to get lost!

Biggest risk is loss of video as switching from FPV flying back to line of sight is disorientating.

Absolute must is a spotter when flying FPV, the world is much different at 100m!

Flying near buildings has high risk of signal loss, WiFi, GSM and private radio systems are working in the same frequency ranges.

Do´s and don'ts

Don't fly solo, you will get lost!

Always have a spotter who understand s the model and environment.

Understand the range limit of your control radio and FPV system

Know your location, it all looks different from 50m up.

Know local flying restrictions.

Don't fly over built-up places and people, always assume the model will fail, where will it land or drop.

Camera may distort distances, wide angle lens will distort your virtual world, it always looks like you have more space.

Examples of my FPV platforms

- Stock (almost) DJI Phantom 450 class equipped with camera.

    - Basic gimal and Gopro
- DJI F550 Flame wheel equipped with:
    - GoPro Black 4
    - DJI Naze MV2 control
    - DJI OSD
    - DJI Data link
    - Eachline ~~200mW~~ 20mW transmitter
    - Tarot Gimbal 2D for camera stabilization
    - 5000mAh LiPo (10-12 min flight time)
- Tek Sumo Wing
    - Eachline ~~200mW~~ 20mW transmitter
    - Mobius HD Camera

Ideas and where it's going

HD FPV / 3D-FPV / FPV over GSM

Whats next, build a 250 quad and lets race!

Aircraft Mass	Airworthiness Approval?	Registration?	Operating Permission?	Pilot Qualification
25kg and less	Vehicle description submitted	Required	Required	Yes + Insurance certificate

UAV operations for civil or commercial purposes is regulated by the European Aviation Safety Agency (EASA). At this moment the institution is in flux while the European RPAS Steering Group(ERSG) is working to set standards across the European Union. A review of the legal guidelines is available here. A new European Commission initiative will explore the civil use of UAVS in more detail as the industry continues to grow

Currently, light RPA (< 150 kg) operations in VLOS (Visual Line of Sight) and E-VLOS are taking place in a number of European countries, but based on non-mutually recognized or harmonized national rules. Such operations can be conducted in all air space classes, but always in visual contact of the remote pilot or an observer. Routine operations are normally allowed outside congested areas, to reduce the risk for people on the ground, while alleviating the airworthiness certification processes for RPAS of small mass (e.g. below 25 Kg). Additional safety requirements and processes apply, when an RPAS operator wishes to fly over densely populated areas. Operations at airports are segregated from other traffic. On a case-by-case basis, IFR operations and demonstrations are carried out under strict conditions and mostly in segregated airspace. Civil commercial operations are already allowed in some member States under the responsibility of an approved RPAS operator. An initial set of common rules on the principles to access non-segregated airspace has been proposed by EASA through NPA 2012-10.