CHATHAM AERONAUTS

EST:1955

FLYING CLUB INC.

FPV

Basics of getting started in First Person View flying.

Presenter: Jeff Vince, Art Reaume, Serge Legare

MAAC rules/guidelines

- MAAC guidelines are laid out in document MAP 09.
- Students are recommended to use a Buddy Box System. Buddy Box operator serves as spotter.
- Once confident, Buddy Box can be eliminated, but Spotter must remain by the FPV pilot at all times during flight. You or spotter must always have direct visual contact with the model.
- Modellers wanting to use more sophisticated models (helicopters, high performance fixed wing) should contact the FPV committee for advice as some have limitations that may prevent sufficient visual imagery to control the model.
- All FPV pilots must have a HAM license to use any FPV frequency.

Why do I need a HAM license?

- Required by Industry Canada. You must have a HAM License or only fly when another member is available that holds a license. The license holder is responsible for the operation of the video transmitter.
- This is required because there are currently no analog video transmitters available that are certified to the RSS-210 standard for license free operation on the license free bands.
- This is regardless of transmitter output power. You can not transmit analog video without a certified transmitter or a HAM radio license. All FPV gear currently available is analog video, so you must have a license.

M.A.A.C. FPV (First Person View) Video Frequency Chart

Available Frequency Bands	Frequency Allocation
900MHz Band	910Mhz
1.2 - 1.3Ghz Band	1258Mhz
	1280Mhz
2.4Ghz Band ** The 2.4Ghz band should not be used for FPV when other RC pilots are operating 2.4GHz RC radios (Spectrum, Futaba Fast, JR, etc.) The operation of 2.4GHz RC radios in parallel with 2.4GHz FPV will interfere with the video signal and will render the video link unusable.	2370Mhz
	2390Mhz
	2410Mhz
	2414Mhz
	2430Mhz
	2432Mhz

5.8Ghz Band

** There are a total of 32 channels organized in 4 channel banks. Channels marked with RED should not be used . They fall outside the frequency spectrum assigned for amateur radio use. If more than one FPV aircraft flies simultaniously, a separation of at least 40-60MHz will be required between frequencies used to avoid signal overlap.

Bank 1	Bank 2	Bank 3	Bank 4
Fatshark Hobbyking	Fatshark Hobbyking	DJI	Fatshark Boscam
5725MHz	5733MHz	5645MHz	5740MHz
5745MHz	5752MHz	5665MHz	5760MHz
5765MHz	5771MHz	5685MHz	5780MHz
5785MHz	5790MHz	5705MHz	5800MHz
5805MHz	5809MHz	5885MHz	5820MHz
5825MHz	5828MHz	5905MHz	5840MHz
5845MHz	5847MHz	5925MHz	5860MHz
5865MHz	5866MHz	5945MHz	5880MHz

910Mhz
1258Mhz
1280Mhz
2370Mhz
2390Mhz
2410Mhz
2414Mhz
2430Mhz
2432Mhz

5725, 5733, 5645, 5740MHz
5745, 5752, 5665, 5760MHz
5765, 5771, 5685, 5780MHz
5785, 5790, 5705, 5800MHz
5805, 5809, 5885, 5820MHz
5825, 5828, 5905, 5840MHz
5845, 5847, 5860MHz
5865, 5866, 5880MHz

Please follow the M.A.A.C. guidelines for FPV flying.

Spotter is required for all FPV flights.

Choosing a frequency band

- 5.8GHz uses the smallest antenna and gives the cleanest picture of the commonly used frequencies. It also has the shortest ranges and suffers (significantly) from multi-path propagation.
- Multi-path propagation is where radio signals reach the receiver via tow or more paths. Reflection, Refraction and ionospheric reflection are common causes.
- In our case, reflection (bouncing signals) is likely the most common. Can cause image fade, ghosting, and jitter.
- 5.8GHz offers the most space for individual channels. Some say 40, some say 32. Practically it’s 8. More on that later.

Choosing a frequency band – Continued.

- 2.4Ghz is often considered the best FPV frequency.
- Gives longer range (at same output power) than 5.8Ghz, as well as a clearer picture.
- 2.4Ghz offers moderate penetrating ability with a small size antenna.
- However, this is the range you control transmitter is operating in. Interference is possible.
- There are 6 “channels” available in the 2.4Ghz range for Video use.

Choosing a frequency band – Continued.

- 1.3Ghz offers excellent penetrating ability and long range.
- However, antenna sizes are not small.
- There are only two “channels” in the 1.3Ghz band.
- 900Mhz offers the longest theoretical range, however the antenna is prohibitively large. This rules out all but suitably large size aircraft.
- 900Mhz is also on the edge of the 3G cell phone band. Interference is possible especially near cell towers (which are pretty much everywhere).
- 900Mhz offers a single channel for video.
- 1.3GHz and 900MHz have been found to introduce servo jitter.

Servo/Video jitter

- 900MHz and 1.3GHz cause a noticeable amount of servo jitter in some servos. Some servos stop working all together.
- Use a ferrite ring and coil up your servo wires or use shielded cables. This works for most servos, but not all. Sometimes you simply need a different servo.

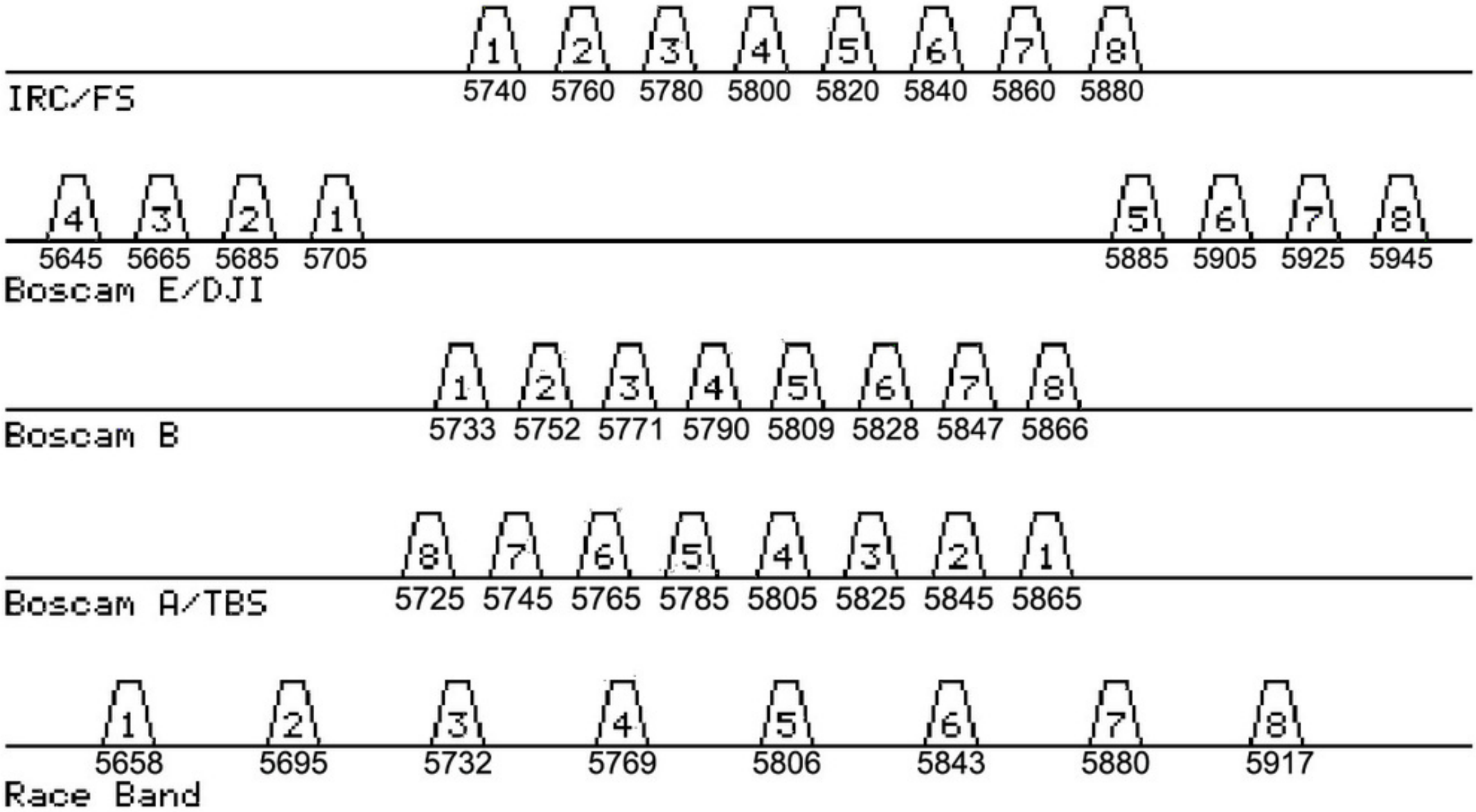
The 5.8GHz channels

- At a high level, we have 6 bands (A through F) with 8 channels each.
- Channels are generally about 20MHz to 40MHz apart in each band, but it varies wildly.
- There doesn't seem to be much of a standard out there:
  - Band A: Team Blacksheep, RangeVideo, SpyHawk, FlyCamOne
  - Band B: FlycamOne
  - Band C (E): Raceband
  - Band E (F): HobbyKing, Foxtech
  - Band E (R): who knows?
  - Band F (Airwave): ImmersionRC, Iftron.
- Here’s the rub: These frequency bands overlap.

More on channels

- Often, unless marked as 32 (or 40) channels, your FPV transmitter and receiver will operate in one Band.
- That gives you 8 channels to choose from to get around others that may be using the same band or another band that has a channel on or very close to yours.
- Lots of RX/TX have 40 channels now, but watch out some of these bands overlap or are very close to each other.

5.8GHz FPV Frequencies



Raceband

- Raceband attempts to get around frequency collisions.
- Does this by having 8 channels spread out across the entire range by roughly 37MHz.
- This provides the maximum usage of the 5.8GHz range by having good separation (avoid collisions), but only provides 8 channels.
- If you want to “Just make it work” approach; buy a RaceBand Rx/TX combo.

Antennas

- Two basic types: Linear and Circular.
- Linear antenna signal is formed in a single plane (think: vertical/horizontal planes)
  - Linear polarization can provide extra range as the energy is focused in one plane.
  - However, that means the antennas need to be aligned for the best signal.
  - This is common antenna type for WiFi. Objects aren’t often moving (much, comparatively)
  - For FPV, this can mean you lose video signal in a turn as the antennas move out of alignment.
    - One remained vertical while the other went horizontal. This means minimal overlap of the signal along the receiver’s antenna.

Circular Polarization.

- If you think of Linear as a wave in X or Y plane moving up/down or back/forth, Circular would look more like a corkscrew.
- This means as the transmitter twists and turns the receiver’s antenna stays in maximum alignment to the signal.
- Circular polarization also helps reject multi-path signals (interference from your own signal bounced off something).

What to use and when

- When to use Circular Polarization
  - For most FPV flying, it’s best to use circular polarization
  - This helps when you’re doing aerobatics or not flying perfectly level for most of your flight
- When to use Linear Polarization
  - When you don’t have the extra space. Linear antennas are smaller.
  - If your aircraft is very stable like a slow flying camera ship.
  - You will get more range with Linear, but only if you antennas remain aligned.

What’s this Right-hand/Left-Hand stuff about?

- Basically if we think of the Circular Polarized signal as moving like a corkscrew through the air: RHCP and LHCP determine which direction it’s turning.
- You must match RHCP and LHCP on both your RX and TX.

Omnidirectional vs Directional

- Think of Omnidirectional as a light bulb and Directional as a flashlight.
- You will get higher gain with directional, but you have to be aimed at the transmitter/receiver. If your aim is off, the gain is considerable worse than omnidirectional.
- For example:
  - Omnidirectional may have a 2.2dBi gain in all directions.
  - Directional may have 6dBi in a narrow (30 degrees) band, 1-2 in other directions and near zero in some (90 degrees off the center line of it's direction for example).
- It's common for very long range FPV to use directional antenna with a model tracking system to keep receiver aimed at model.

A word about range.

- Lots of stuff can effect range; local transmitters, power lines, antenna design, etc, etc, etc. Consider this a very basic guideline for transmitter power:
  - 10mw 5.8GHz with Cloverleaf: 310 meters (0.2 mile)
  - 25mw 5.8GHz with Cloverleaf: 500 meters (0.3 mile)
  - 50mw 5.8GHz with Cloverleaf: 700 meters (0.4 mile)
  - 10mw 5.8GHz with Cloverleaf: 310 meters (0.2 mile)
  - 100mw 5.8GHz with Cloverleaf: 1km (0.6 mile)
  - 250mw 5.8GHz with Cloverleaf: 1.6 km (1 mile)
  - 600mw 5.8GHz with Cloverleaf: 2.4km (1.5 mile)
- Source: http://www.maxmyrange.com/
- Keep in mind your control transmitter range. Spektrum says a full range test is 1km at ground level. Use that as a rough estimate of how far you'll have control.

Ok, I’m in. What do I need to start?

- Let’s assume you have an aircraft in mind, you need:
- Camera.
  - Usually 600-700TVL (television lines). Be aware of cameras that offer super high TVL. Analog video tops out around 700TVL, anything marked over that is likely misrepresented.
  - Watch what voltage the camera needs. 5 and 12v are common. Some work down to 3. Usually your transmitter will provide power to the camera, so match what it provides.
- Viewing device
  - Three common approaches: Goggles, Headset, or Screen.
  - May include a receiver or use an external one. Watch what you’re buying.
  - Really comes down to what you like. Swing by the field and try some options before you buy

What you need. Continued.

- Transmitter for the aircraft.
  - Needs to match your receiver of course.
  - This can mean picking a band/vendor and sourcing everything from them. Consider Raceband as it’s supported by multiple vendors and gives good channel separation
  - The transmitter may provide power to your camera in the same connection. Watch the voltage output. Hooking a 5v camera to a 12v transmitter will let out magic smoke.
- Antennas. Your Rx and Tx will likely come with directional antennas. Consider getting omnidirectional “cloverleaf” antennas for better video. RHCP or LHCP is your choice, just stick with one. Right-hand seems to be more popular (more vendors offering it).

What you need. Continued even more

- HAM license. Just requires a simple test. Industry Canada has a listing of examiners online. Several sites recommend preparing by using the ExHAMiner software (free download) and taking practice tests until you master all the questions.
- Spotter. MAAC requires you have eyes on the aircraft at all times. This means always having spotter and flying only in line of sight regardless of how good your video feed is.

Other stuff to consider

- A ground station with LCD panel and (optional) directional antenna. This can give you the best range. Be aware you may need to move to a high power HAM band radio for control. You will fly out of standard 2.4GHz range.
- Antenna designs. Omnidirectional Cloverleaf are popular and work well, but there are lots of other options that will work better in some instances. Be forewarned, you may want an EE degree to understand some of the math down this particular rabbit hole.
- Onboard OSD and GPS. Many vendors are offering on screen display modules that add telemetry and onboard stats like voltage to your display. GPS takes this a level higher and can offer a directional compass to guide you home.
- Watch your range. Higher power video transmitters can produce a signal farther than your 2.4Ghz or 72MHz radio. Nothing worse than watching first person as your plane flies away never to be seen again.