FPV


# BRITISH MODEL FLYING ASSOCIATION

# THE R/C ACHIEVEMENT SCHEME

## TEST STANDARDS for CHIEF EXAMINERS and CLUB EXAMINERS

## GUIDANCE for TEST CANDIDATES

## THE MULTI-ROTOR & FIXED WING FPV EXTENSION CERTIFICATES (FPV Extensions)

## 2017 ISSUE

## General

The Achievement Scheme is run by the BMFA as a National Scheme and it is open to all model flyers. Where a non-member wishes to participate in the achievement scheme the examiner who will be conducting the test must inform the BMFA office via email or telephone no later than the day prior to the test being carried out of the non-member's full name, address and the date that the test will be conducted. This enables the BMFA to extend insurance at suitable levels for the day of the test. If this procedure is not followed the test will be invalid.

The examination for an FPV Extension to an existing Certificate may be taken on application to **any** Registered Examiner.

In order to be able to take an FPV Extension Certificate, the candidates must hold, an 'A' certificate or BPC in the relevant discipline.

**The candidate must successfully complete the test schedules in one attempt. A maximum of two attempts at the examination are permitted in any one day.**

The test schedule is split broadly into five areas; the pre-flight safety checks, moving from the pits/start-up area to the take-off/landing area, the flying manoeuvres, the recovery & return to the pits, and the questions.

### First Person View Extension Certificate (FPV Extension) Certificate

The FPV Extension Certificate is a measure of flying ability and safety which "may be equated to a safe solo standard of FPV flying."

**The test for the FPV Extension is based on a simplified version of the 'A' test for the relevant discipline, however there is a specific test form for the FPV Extension, that is available from the office and can also be downloaded from the BMFA website downloads page.**

As an Examiner, the level of competence you should expect of a candidate should be based on that criterion; that is 'is this person, in your opinion, fit to be allowed to fly FPV unsupervised'.

The candidate should have studied the BMFA handbook, CAP 658, the Safety Code for FPV flying, any local site rules (if applicable) and be familiar with the 'Safety Code for General Flying' and the 'Operational Guide, All Models and Radio Control'. Besides being an excellent guide to the safe flying of model aircraft, most of the questions asked at the end of the test will be from these sections of the handbook and CAP 658.

There is a section in the Handbook that gives the relevant page numbers of these sections but remember that addendum sheets to the Handbook are published in BMFA News and on the BMFA website and these may also be relevant as they contain up-to-date information.

Also be aware that you may ask questions on any local site rules that the candidate should be aware of and these may form an important part of the test questions you ask.

## Outdoors

The test may not be flown indoors. It was designed to be flown outdoors and the text of the test manoeuvres highlights this. It is important to remind candidates that their ability to cope with various wind conditions is an integral part of the test.

## The Model

The FPV Extension tests can be performed with virtually any fixed wing or multi-rotor aircraft, **with a total mass (including flight batteries and or fuel) of less than 3.5 kg** and hence does not require an operator on a buddy-box lead. A multi-rotor for the benefit of this test is defined as a rotorcraft with three or more rotors. Whatever model is brought by the candidate, it must be suitable to fly the manoeuvres required by the test they are taking. You do not have the authority to alter the required manoeuvres to suit a model and if, in your opinion, the model is unsuitable for the test then you should explain this to the candidate and tell them that they cannot use that model. The selection of the model to do the test is the responsibility of the pilot and it is their ability you are testing, not the model.
On no account may the candidate use defects or limitations in the performance of the model as an excuse for poor performance on their part and you should make no allowance on this point. The type of model presented cannot be used as an excuse for not completing certain manoeuvres.
Electric Powered Models must be treated as LIVE as soon as the main flight battery is connected, irrespective of radio state and great care must be demonstrated by the candidate. The arming sequence should be clearly understood and discussed/demonstrated to you by the candidate.

## Competent Observer

The Examiner **must not** fulfil the role of the Competent Observer for the test. The candidate will be expected to provide their own individual. Ideally this will be someone they have used in this role previously and or flown with regularly. The candidate will be expected to provide a detailed brief to the competent observer, regarding their role and responsibilities, prior to the test. As a minimum, this will include any local rules and or limitations associated with the site that might impact on the test, as well as the positions of any relevant no-fly zone(s).
The candidate must give due consideration to any input provided by the competent observer during the test. However, the competent observer should not need to make repeated inputs and the candidate should not be over-reliant on their input. The candidate must be able to demonstrate sufficient spatial awareness to remain in a safe flying area and not infringe any no-fly zone(s) without requiring repeated inputs. The examiner should warn both the pilot and the competent observer if he feels the level of input from the competent observer is too high.
At some point during the test the Examiner will make an input as competent observer and the candidate will be expected to take appropriate action, as required. Example inputs might be; an individual walking out onto the flying area, an airspace incursion by another aircraft, or incapacitation of the competent person.

## Buddy Box Systems

Buddy leads and other dual control training aids must not be used during any achievement scheme test.

## Gyros, Electronic Stabilisation and GPS

It is acceptable to use an electro-mechanical or solid state gyro/s in a model being used to take the test although electronic stabilisation is restricted to flight enabling and self levelling only. This allows a range of flight controllers / gyros to be fitted, from simple yaw dampers to solid state heading lock units.
The use of any autopilot, GPS and/or waypoint programming, which may or may not be designed into such units beyond the definition above, is not acceptable during the test.

Candidates should be prepared to explain the capabilities of the system they are using and show that it does not take over control from the pilot and that automated flight will not be achieved during the test.

**GPS must not be used during any test.**

## Height and Speed

The FPV Extension certificate candidate should be a reasonably confident pilot, even though they may have been flying for only a few months. FPV flying differs from line-of-sight flying in that the pilot sees a completely different perspective and, especially during initial flights, it is easy to lose track of where the aircraft is relative to the flying field. Flying too close or too far away is not the mark of a confident pilot. Height control is one of the more demanding aspects of FPV flying (particularly for Multi-rotors) and reasonable allowance should be made for this. However, the test should be flown at the heights specified in the individual elements without drastic deviation.
The manoeuvres in the test require slightly different speeds as will be explained on the manoeuvre descriptions.

The lazy eight portion of the Multi-rotor test should be flown with the model at a height of approximately 10 feet. The flying sections should typically be completed at a height of between twenty to forty five feet (roughly one to two houses high). The pilot should show good use of the controls to maintain a constant height throughout each of the separate elements of the test and transitions between various heights should be smooth and steady. Height selection and control are important factors, as mentioned above.

## Wind Direction

There is no requirement for the fixed positioning of manoeuvres relative to the wind direction in the Multi-rotor FPV Extension test and you will find no reference to the wind in the text of either the test or this Standards Document.

**This makes it absolutely ESSENTIAL that you discuss this with the candidate at length so that you are both aware of exactly how you want the manoeuvres to be presented and what limitations will be accepted if the wind direction is not favourable.**

## Consistency

Good use of the controls should ensure that the model stays at a reasonably constant height, and moves at a steady speed suitable to each of the separate elements of the test. All deviations from these constants should be noted, and will form part of the judgment of the test.

Unnecessary varying of height and inconsistent lines are valid reasons to fail a candidate at this level as they give a good indication of the flyer's general level of competence and they must strongly influence your final decision. Poorly flown height or lines are a sure sign that the flyer has either not practiced the test or has not reached the required standard of flying and are legitimate reasons to fail them.

## Continuity

For the FPV Extension test the manoeuvres are set out in such a way that they are flown one after the other as a short sequence. You should discuss with the candidate before the flight the way in which you would like the various elements flown and the candidate should have a good knowledge of the test before the event. If the candidate is very hesitant during the test and is not capable of following the set sequence then you might conclude that they have either not had enough practice or that their basic flying skills are not yet well enough developed.

Although the manoeuvres are set out as a sequence, it is **ABSOLUTELY NOT** expected that they will be flown as a schedule with one manoeuvre flowing into the next. The candidate may opt to fly the test in that manner but that is their choice. Most flights will have a combination of

transitions and positioning circuits between the various elements and you should note any additional flying for positioning etc., just as carefully as the rest of the flight, as this can say much about the competence of the pilot.

A pilot who transitions directly from one manoeuvre to the next is not to be penalised as this is quite acceptable, but watch out for the pilot who is not sufficiently practiced. Flying some of the manoeuvres in this manner can get them into some very awkward positions. The candidate should have a good knowledge of the test before the event.

It should be possible to fly the test on one flight battery (or tank of fuel) but if the model does have to have the flight battery changed (or refuelled) then the pilot must clear this with you before the test starts as required by the test procedure. It is allowable only once during the test and anything the pilot does during this time must be considered by you to be part of the test. This includes the way they land, retrieve, carry out and take off. With I/C models the correct re-fuelling and start procedures must be used, For electric models, isolating the flight battery before carrying the model in and not re-connecting until the model has been carried out to an appropriate safe point are important.

## Trim

It is expected that the candidate will start the test with a model that has been trimmed out previously but, if necessary, they should be able to trim the model out relatively quickly. If you see obvious signs that the model is out of trim and the candidate makes no attempt to rectify the matter, you may well question their basic competence. On the other hand, if they do need to re-trim and are making attempts to do so, you should make allowances for a short time of flight with a somewhat erratic path. This should not be penalised unless it puts the model in any dangerous situations or unless the model flies behind the pilot or into any other unsafe area. If the pilot does use the first part of the flight as a trimming exercise, they should be required to land as soon as they are satisfied with the trim and the test should then commence at manoeuvre (b). If a flight is abandoned prior to starting manoeuvre (b) because of trim problems it will not count as a test flight attempt.

## Nerves

Quiet competence is what you are looking for during the flight, but most candidates may well be nervous and you should make some allowance for this. If the flyer is very nervous you should seriously consider abandoning the test for the time being and arranging a coaching flight or two to settle the candidate down before re-taking the test. This can be done on the same day and can really help those candidates who have trouble with nerves when flying in a test situation.

## Repeating Manoeuvres

The manoeuvres for the FPV Extensions are fairly simple and the candidate should be competent to fly them with very few errors. If you see any major faults the test should be taken again. It may be, however, that the candidate will make a **minor** mistake on a manoeuvre and if you are not fully satisfied with what you have seen you should consider asking for the manoeuvre to be repeated.

Some judgement is called for on your part here. A **major** mistake, such as infringing any no-fly zone, is grounds for failing the candidate, especially if loss of control has occurred or a dangerous situation has arisen. You should definitely not let them have multiple attempts at each manoeuvre until they get it right but you must give yourself the best chance of assessing the competence of the pilot you are testing.

You should consider what you have seen the model do and if you think to yourself "could be better" than a request that the manoeuvre be repeated may be considered. Be extremely careful about using this option, however, as you could very easily be degrading the worth of the test. It must not, under any circumstances, degenerate into a series of 'practice' manoeuvres.

## Repeating the test

The rules allow two attempts at the test in one day and if the candidate fails the first of these you must consider their performance in deciding what to do next. Many failures will be reasonably good or borderline cases and in these circumstances it may be appropriate to allow the candidate one or two practice flights before repeating the test. Remember that many of the candidates will be unfamiliar with flying under pressure and might do very well on the second test.

However, it will probably be obvious to you on many occasions that the pilot you are testing is simply not ready for the test they are taking. In this situation it is better that you tell them so quite clearly. If possible, it might then be useful to suggest that they arrange a demonstration by an experienced flyer who has passed the test, so that they can gain an understanding of the standard of flying that is required, especially if they are not clear about the manoeuvres and the positioning for them. This is far more useful to everyone than simply telling the candidate that they have failed.

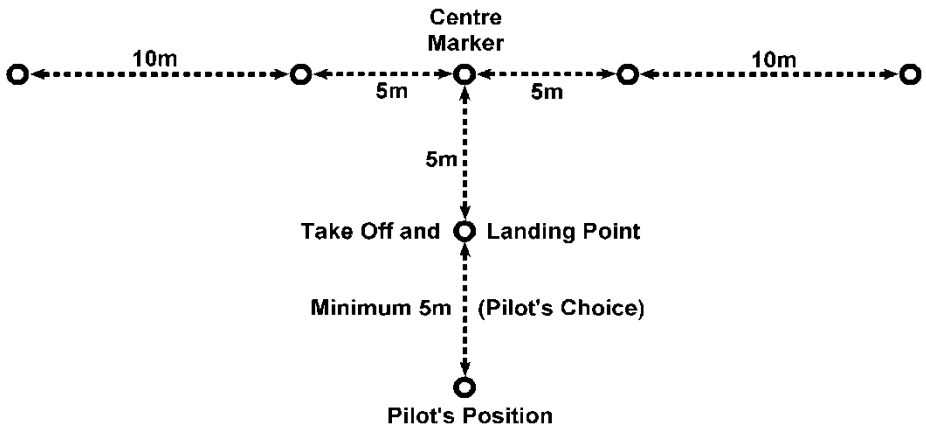
A flight which is abandoned for any reason prior to starting manoeuvre (b) will not count as a test flight attempt

## Interruptions to the Test

A possibility that may occur during a test is a motor failure part way through, which with multi-rotors could very well lead to a damaged model. If this is the case then the test obviously cannot continue and you should invoke the rule that the test should be performed in one flight and count the flight as one of the two attempts allowed during the day.
Genuine motor trouble or even motor-out situations during the test may be dealt with in one of three ways.
If the test was being generally flown in a satisfactory manner and the problem can be rectified quickly then the candidate may be allowed to continue the test from the start of the manoeuvre in which the problem occurred.
If the problem cannot be rectified quickly but you consider that it was a genuine unforeseen occurrence, you may annul the test and not count it as one of the two attempts.
If the test up to the point of failure was not satisfactory, you have the option to cancel the rest of the test and count the flight as one of the two attempts allowed during the day.
Obviously, you will have to use your judgment on this matter as there will rarely be black and white situations but how they handled the emergency should be of great interest to you when you come to review the candidate’s overall standard of flying.

## Ground Positioning

When taking a multi-rotor FPV Extension test, it is your responsibility as the Examiner to lay out a series of ground markers to assist both the candidate and yourself to assess the manoeuvres being flown. Small cones, canes or any other similar marker may be used as long as they don't interfere with the flying of the model. However, it is vital that the marker used for the take off/landing point (TOLP) does not affect the model at all and probably the best marker in this case would be something like the fluorescent discs that lay flat on the ground. Alternatively, you could use some of the biodegradable ground marker spray paint that is readily available.
The layout of markers required is shown below and it must be emphasised that absolute accuracy of distance is not required when setting them out. Pacing will be quite accurate enough. It is essential, though, that the centre marker, the TOLP and the pilot's position are in line.




GROUND POSITIONING MARKERS

The general positioning of the markers will depend very much on the geography of the flying site and safe operation of the model and you should set them out with these factors in mind.

It is not a requirement that the markers in the cross bar are used by the pilot but they are there to help. However, the centre marker, the takeoff/landing point and the pilot's position must be used with some accuracy.

For Multi-rotors, the landings should generally be no more than a metre or two from the takeoff/landing point. The pilots is expected to stay close to the selected pilot's position and may be seated if they wish.

Remember that it is a requirement that 'all manoeuvres are carried out in front of the pilot' so their perception and awareness of their own position is important.

## General Manoeuvres and Hovering

FPV flight may be conducted by the use of either goggles or a screen. For the Fixed Wing FPV Extension Certificate, take-offs may be made either Line Of Sight (LOS) or First Person View (FPV) at the discretion of the candidate. This is in recognition that many fixed wing FPV aircraft don't have an undercarriage and hence require a hand launch. A hand launch and subsequent return to the pilot box whilst in FPV mode would be unsafe.
All take-offs and landings should be smooth, without undue oscillations, and climbs and descents should be straight and controlled with the model a comfortable and safe distance in front of the pilot. Due to the nature of the flight control systems (and sometimes the position of the camera) the touch-down of a Multi-rotor aircraft will generally be more 'abrupt' than for a conventional helicopter or fixed wing aircraft. Candidates should not be penalised for any minor bounce or oscillation at the point of touch-down, but the candidate should fail if the Multi-rotor turns over on landing.

In any stationary hovering the model should remain steady and should not oscillate unduly.
The standard 'brief' hover time is about five seconds. You should discuss this with the candidate before the test so that they know that you will want to see a positive stop with the hover long enough to show that the model is well controlled and steady with little wandering or oscillation. Stopwatch accuracy is not required.
The candidate should also be aware that the decision to move on is theirs and that you will not be asking them to commence with the next manoeuvre. However, during your pre-flight briefing, they may ask that you indicate when you are satisfied that they have completed their 'brief' hover times to help them decide when to move on. This is quite permissible if requested by the candidate.
Circuit and other 'flying' manoeuvres should be performed at the heights mentioned in 'Height and Speed' above. Movement of the model from one point to another whilst in the hover should be done at a steady walking pace.

Care should be taken in the flying manoeuvres that the line of approach and height each time is consistent and you should take particular note of performance in this area.

## Intermediate Landing

Exceptionally, at a pre-determined point in the flight an intermediate landing may be permitted for the sole purpose of refuelling or the fitting of a freshly charged flight battery. This landing may only be made with the prior consent of the Examiner. The pre-determined point may be either after a specific manoeuvre or at a specific time of flight, whichever is requested by the candidate and agreed by the Examiner.

Full pre and post flight checks are not normally required during an intermediate landing and takeoff unless the model suffered a hard landing. However, the candidate should give the model at least a quick visual examination whilst on the ground.

## Helpers for Disabled Candidates, Young Candidates and Others Who have Requested Help During the Test

When disabled or young candidates present themselves for the test it may be that they will not physically be able to perform all the actions that most candidates can. At times, other candidates may also request help with certain physical aspects during the test (they may, for instance, have an injured finger). There will be times when you, as an Examiner, will think 'how much can I relax the test requirements for this person'.

Some Examiners make the decision to make no allowances at all but this effectively bars many people from attempting the tests. If we think of the achievement scheme as a true national scheme then we must consider how we can accommodate candidates, not how we can stop them from participating.

The answer, of course, is that you, as an Examiner, must make on-the-spot decisions about what you will allow during the test and, in such cases, you are within your authority to take such decisions. The guidelines set out below may help but at all times the two items at the end of this section must take precedence. They are not negotiable and mean that, whoever the candidate is, they have to convince you that they know what they are doing or what is happening for the full duration of the test.

For instance, a disabled flyer may have difficulty handling the model and may not be able to carry it out to the strip, release it for launch or retrieve it after the flight. The sensible use of a helper is certainly allowable in such cases but it is essential that they only do what the candidate asks them to do. Pre-flight checks and engine starting may be another problem area that can be overcome by a helper but you should expect the candidate to do as much of the work as possible themselves and they should be able to talk you through anything that the helper does for them. Be sure to discuss all this with the candidate before starting the test.

All of these comments can apply to younger flyers too but there is an added complication with engine starting. Many parents are very unhappy about letting their children near a running engine and will not allow them to start their own engines. This is a perfectly valid view and, again, is a case where a helper can be used. If this situation does occur with the younger candidates, however, you should insist that they do all the pre-flight and preparation work themselves, up to applying the starter to the engine. If they cannot do this then they should not pass.

After engine start, the helper can adjust engine controls and carry the model but only on the instructions of the candidate.

**In all cases:**

**(1) If, at any time, the helper takes over the decision making process from the candidate then the candidate must fail.**

**(2) You can make no allowances whatsoever for anyone during the flying of the test. The candidate can either perform the flight manoeuvres as specified or they can't. If they can't then they must not be passed.**

Make sure in your briefing that both the candidate and the helper are fully aware of both of these points.

# The Multi-rotor FPV Extension Test

**(a) Carry out pre-flight checks as required by the BMFA Safety Codes and BMFA Multi-rotor Certification Appendix document. See appendix 5.**

The pre-flight checks are laid out clearly in the BMFA Multi-rotor Certification Appendix document. The candidate should also go through the pre-flying session checks, laid out in the BMFA handbook. Ask the candidate to go through their checks as if the test was their first flight of the day.

Points to look for are that the candidate has a steady and regular ground routine, especially when starting and tuning the engine. Nerves should not play a part in the pits, and you should satisfy yourself that the candidate is in full control of what they are doing whilst preparing the helicopter for flight.

A tidy flight box and a neat ground layout makes a good impression but bear in mind that that candidates may not have been flying for too long and you should make allowances.

A poor performance in this area is not direct grounds for failing the candidate but can certainly be part of a cumulative fail if other aspects of the performance are below the standard you expect.

Pay particular attention to the way the candidate uses the local frequency control system and make sure that they fully understand it and use the correct sequence appropriate to their model. For 35 MHz, this is usually 'get the peg, Tx on, Rx on'. For 2.4 GHz, the candidate should be aware of any local transmitter usage limitations and if a flight peg is required, it must be obtained before the usual Tx on, Rx on sequence. Some radio equipment and, occasionally, a specific model requirement requires that the Rx be switched on first and, if this is the case, the candidate should explain this clearly to you.

Attention should also be paid to the frequency that the pilot intends to use for their FPV equipment. The pilot must comply with any local video frequency control system, where applicable. In addition they should understand that switching their FPV equipment on while other pilots are flying FPV could result in a pilot losing video signal, so they should check that the frequency/channel they intend to use is clear before switching on.

With electric powered models, take note that the candidate is aware that the model is ‘live’ as soon as the flight battery is plugged in and that they take appropriate safety precautions. If a separate receiver battery is fitted, the candidate should have the opportunity to check the operation of the radio equipment before the flight battery is plugged in.
Watch carefully and take note that the transmitter controls, trims and switches are checked by the pilot.

All candidates are required to be aware of the local frequency control system and anyone who is required to use it but switches their radio on before doing so should be failed on the spot.

Electric powered models must be carried out from the pits area to a safe point before the flight battery is connected and they MUST be considered live as soon as the flight battery is plugged in. Great care should be taken at this point and any help available to the candidate should be used in the interests of safety.

The pilot must demonstrate the correct function of the failsafe, where appropriate, before committing to the flight.

If there is no one else available then there is nothing to stop you aiding the candidate by, for instance, carrying the model to the test area etc. but any such actions must be performed by you directly on the instructions of the candidate. You must not prompt them or carry out any actions of your own accord.

It is important that you talk these points over with the candidate in you pre-flight briefing.

During the course of manoeuvres (b) to (h) the model should not deviate significantly from the desired path. Slight drifting may be permissible in adverse wind conditions, but should be rapidly corrected. If the deviation is severe, or the model does not follow the correct path, the candidate should not pass. The flying speed is at the discretion of the candidate, but must be no slower than a fast walk.

Each stop should be a controlled hover, with any movement being quickly checked, without signs of large over-corrections. The pauses at each hovering point should be about five seconds.

The height of the multi-rotor should be consistent throughout the manoeuvres and close to the specified heights.

Before commencing this manoeuvre, the pilot must check with the Competent Observer that the airspace is clear and announce his intentions to the other pilots. Take off should be smooth and the lift to 10 feet should be vertical, straight and controlled with the model a comfortable and safe distance in front of the pilot. Once at 10 feet the model should remain stationary and should not oscillate unduly. You should notify the candidate when the hover time of about twenty seconds has passed and ask him to commence with the next part of the manoeuvre. The descent and landing should be smooth and steady with little oscillation on touchdown.

(b) Take off and fly slowly forward for approximately 5 metres, then turn 90 degrees either left or right and fly forward to perform two ‘lazy eights’, each at least 30 metres in length. The pilot should be aware of their position in the air, particularly in relation to the field layout and pilot box, and not cut inside of the cones marking out the end of the 30 meter ‘lazy eights’. The pilot must fly round the cones as shown in the diagram.

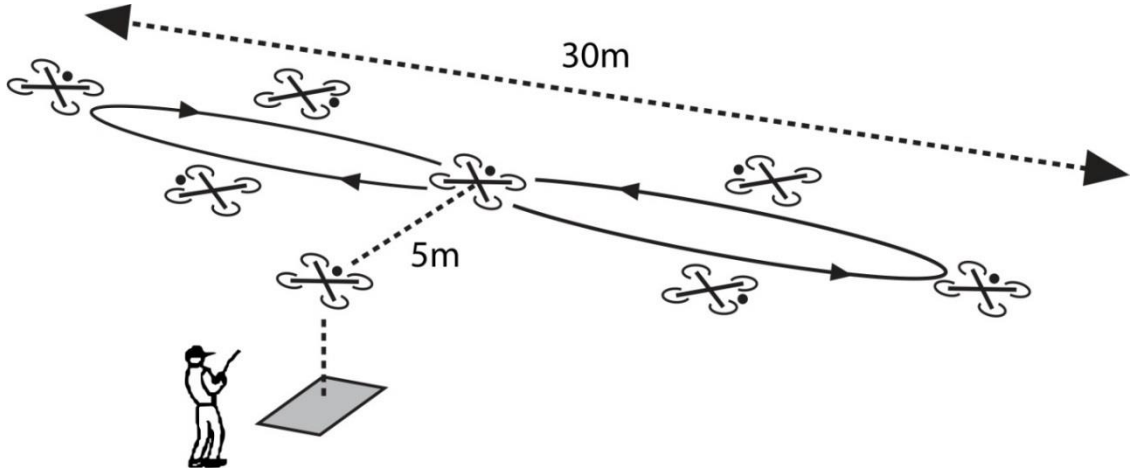
Before commencing this manoeuvre, the pilot must check with the Competent Observer that the airspace is clear and announce his intentions to the other pilots The pilot should fly this manoeuvre at a safe height above eye level, but should not fly at such a height that the model cannot be clearly seen by the Examiner. Between ten and twenty feet is the correct height band for this part of the test and the model **must** fly through the lazy eights, not hover them. The pilot must be clear about the height at which they wish to fly before they take-off and you should discuss this with them in the pre-flight briefing.

Having ensured that it is safe to start the manoeuvre, the pilot then takes the model off, rises smoothly to the flight level previously selected and hovers forwards for approximately 5 metres, to a position over the centre marker. At no time during the take off should the model drift backwards towards the pilot box.

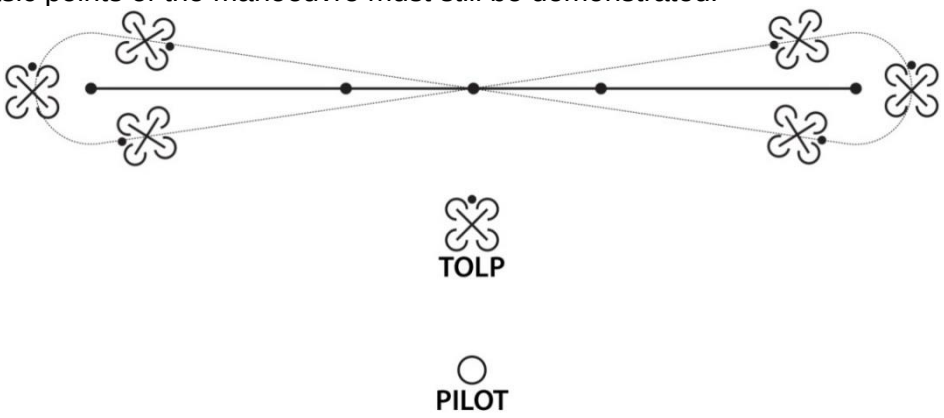
The pilot then turns the model 90 degrees, either left or right and, at the same time, accelerates forward. It is not required that the 90 degrees turn is completed before the model accelerates; the turn and acceleration may be one smooth manoeuvre although the pilot may treat them as separate manoeuvres if they wish.

The pilot moves away at his chosen height for a distance of about fifteen metres where they begin a turn the model smoothly through 180o, flying forward all the time, and bringing the model back across in front of them. Without hesitation the model continues at the same speed in the new direction until it has flown past the pilot for a further fifteen metres to his opposite side. At this point he smoothly executes another 180° turn, causing the model to be now moving in the same direction as the first leg, again moving forward across in front of the pilot.

The model does not stop at this point but it then repeats the events of the first lazy eight until two full eights have almost been completed and the model is near or over the centre ground marker.




During the lazy eights, you will be looking for a safe controlled flight throughout. The candidate should not lose or gain height significantly on the turns and should fly in a straight line between the turns with only sufficient drift on the model to prevent the it from moving either further away or, more dangerously, closer to himself during each leg of the manoeuvre. The **overall** length of each eight should be at least thirty metres and the model must be sideways on to the pilot each time it passes across their front. Some allowance can be made for a strong or gusty wind but the basic points of the manoeuvre must still be demonstrated.




The turns should be made by use of cyclic and rudder co-ordinated correctly, and must **not** be half pirouettes at the end of each leg. The flight pattern should be as per the diagram shown above and should not deviate significantly from it. The pilot should be equally competent to the left and to the right when flying this manoeuvre. If any significant difference in their flying skills shows up here then you should seriously consider whether they show the degree of competence necessary. It should be borne in mind that the manoeuvres in the test have been made reasonably simple, so that a fairly high degree of control can be demanded.

**(c) At the conclusion of the two 'lazy eights', bring the multi-rotor to a halt sideways-on over the centre marker** and then turn back towards the take off point and land.

At this point the model should be approaching the area of the centre marker, still at the chosen manoeuvre height, and the pilot should aim to smoothly decelerate the model to a brief stop over the marker. The model is then flown to a landing at the original take-off point. The orientation of the model for this manoeuvre is entirely at the discretion of the pilot and will depend critically on the orientation/position of the camera. You should take the opportunity to watch carefully for a smooth well-thought-out and safe manoeuvre.

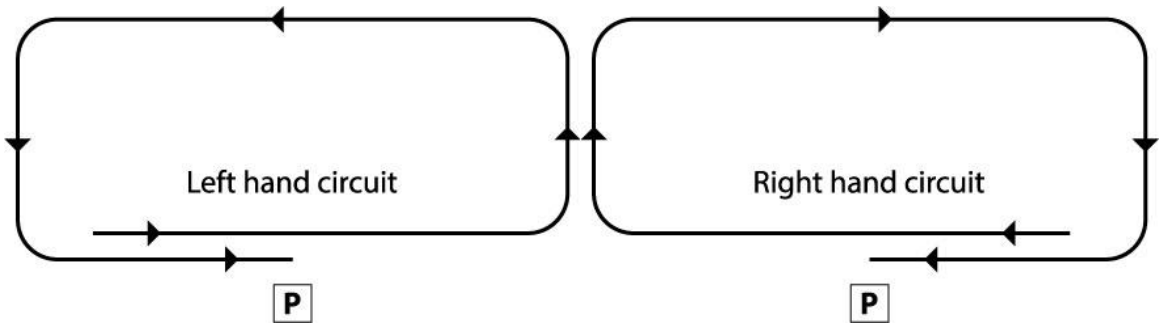
**(d) Take off and climb to a safe altitude.**
Before commencing this manoeuvre, the pilot must check with the Competent Observer that the airspace is clear and announce his intentions to any other pilots. On taking-off, the Multi-rotor should lift to a brief hover between approximately 5 and ten feet. The pilot then climbs out at an angle of approximately 45° to his selected safe height. When reaching this height the model can be transitioned into forward flight and the pilot can now position it for either a left or right hand circuit as he pleases. During the climb out you will be looking for a positive approach to the manoeuvre, a constant angle and velocity.

**(e) Fly a left hand rectangular circuit.**

**(f) Fly a right hand rectangular circuit.**

The pilot can elect to fly these manoeuvres in either order, however, before commencing this manoeuvre, the pilot must check with the competent observer that the airspace is clear and announce his intentions to any other pilots as one of the circuits will inevitably be in opposition to the normal circuit direction.

The circuits should be rectangular as shown in the manoeuvre diagrams. The circuits should typically be completed at a height of between and twenty to forty five feet (roughly one to two houses high). The longest legs of the circuit must extend over at least fifty metres. It is important that the initial turn on each circuit is made away from the flight line and the model must never pass behind the pilot. On the run in to the first circuit and on completion of it, the model will be flying past the front of the pilot, and, for safety reasons, twenty or thirty metres out from the take off area.
Agree with the candidate prior to the test the approximate initial line they should follow. You must both be clear on this, as the line will be established to avoid any incursion into no-fly airspace, specifically any area behind the pilot and or flight line. The first pass in front of the pilot is extremely important, as it sets the standard height and line for the second circuit.



**(g) At the conclusion of the two rectangular circuits the multi-rotor should descend smoothly and come to a controlled stop over the centre marker. The multi-rotor should then fly to a landing on the original take off point.**

Before commencing this manoeuvre, the pilot must check with the Competent Observer that the airspace is clear and announce his intentions to any other pilots. The pilot should aim to smoothly descend and decelerate the model to a stop in front of the pilot position. At this point it should be over the centre marker, about five metres in front of the TOLP and hovering at approximately ten feet.
The model is now flown to a landing at the original take-off point. The path taken is entirely at the discretion of the pilot and you should take the opportunity to watch carefully for a smooth well-thought-out and safe manoeuvre.
After landing, the candidate should shut down the motor(s) and allow the rotor blades to stop turning before collecting the model to return to the pits.
Remember that electric models must be assumed to be 'live' until the flight battery has been disconnected and the handling of the aircraft by the candidate must reflect this during retrieval and in the pits area.

**(h) Complete post flight checks as required by the BMFA Safety Codes.**

These are clearly set out in the BMFA Members' Handbook and BMFA Multi-rotor Certification Appendix document, but you should pay particular attention to the correct Rx off, Tx off sequence and ensure that the frequency control system in use is cleared correctly.

# The Fixed Wing FPV Extension Test

## (a) Carry out pre-flight checks as required by the BMFA safety codes.

The pre-flight checks are laid out clearly in the BMFA handbook. The candidate should also go through the pre-flying session checks, also laid out in the handbook. Ask the candidate to go through their checks as if the test flight was their first flight of the day. Particular attention should be given to airframe, control linkages and surfaces.

Points to look for are that the candidate has a steady and regular ground routine, especially when starting and tuning the engine. Nerves may play a part in the pits but you should satisfy yourself that the candidate is actually in control of what they are doing when preparing their aircraft for flight.

A neat ground layout makes a good impression but bear in mind that many candidates may not have been flying for too long and you should be prepared to make allowances. A poor performance in this area is not grounds for failing the candidate, however, but it is inevitable that you will be making mental notes of all aspects of the candidate's competence and this is one that might have an effect on a real 'borderline' case.

Pay particular attention to the way the candidate uses the local frequency control system and make sure that they fully understand it and use the correct sequence appropriate to their model. For 35 MHz, this is usually 'get the peg, Tx on, Rx on'. For 2.4 GHz, the candidate should be aware of any local transmitter usage limitations and if a flight peg is required, it must be obtained before the Tx is turned on. Some radio equipment and, occasionally, a specific model requirement requires that the Rx be switched on first and, if this is the case, the candidate should explain this clearly to you.

Attention should also be paid to the frequency that the pilot intends to use for their FPV equipment. The pilot must comply with any local video frequency control system, where applicable. In addition they should understand that switching their FPV equipment on while other pilots are flying FPV could result in a pilot losing video signal, so they should check that the frequency/channel they intend to use is clear before switching on.

With electric powered models, take note that the candidate is aware that the model is 'live' as soon as the flight battery is plugged in and that they take appropriate safety precautions. If a separate receiver battery is fitted, the candidate should have the opportunity to check the operation of the radio equipment before the flight battery is plugged in.

Watch carefully and take note that the transmitter controls, trims and switches are checked by the pilot.

All candidates are required to be aware of the local the frequency control system and anyone who is required to use it but switches their radio on before doing so should be failed on the spot.

If there is no one else available then there is nothing to stop you aiding the candidate by holding the model for the power check, carrying it out for take-off etc. but any such actions must be performed by you directly on the instructions of the candidate. You must not prompt them or carry out any actions of your own accord. Talk this over with the candidate in your pre-flight briefing.

If the test is being taken with an electric powered model then the candidate should show that they are familiar with the safe handling of such models.

In particular they must demonstrate to you the 'arming' sequence for their model. For safety reasons many speed controllers have a pre-programmed sequence of actions that have to be followed before the motor will respond to throttle stick movements. For instance, after switching on Tx and Rx and then plugging in the main flight battery, one type of controller

requires that you move the throttle stick from low to full throttle and then back to low before the motor is ‘armed’ and ready for flight.

The candidate must be fully familiar with the system fitted to the model and should brief you on the system and demonstrate it working at some time during the pre-flight checks.

Generally, they must show that they are paying particular attention to the transmitter and receiver switch on sequence and they must make you aware that they are treating the model as ‘live’ as soon as the flight battery is plugged in, no matter what arming sequence they may then have to go through.

The pilot must demonstrate the correct function of the failsafe, where appropriate, before committing to the flight.

**After the take off, the pilot must remain in the designated pilot area for the entirety of the flying part of the test.**

### (b) Take off and complete a left (or right) hand circuit and overfly the take-off area.

The model may be carried out to the take off position by the candidate or a helper or it may be taxied out from a safe position in front of the pits/pilots area**. Taxiing out of the pits is an instant fail**. Prior to carrying or taxiing out, the pilot should inform other pilots flying that his model is going out onto the active area.

Take off must be performed with the model a safe distance from the pilot box area and on a line which does not take the model towards the pits, other people or any other danger/no fly area.

A hand launch (either by the candidate or helper) is permissible for the fixed wing FPV extension certificate, as the take off may be conducted FPV or LOS.

Take off should be reasonably straight with the model not being climbed too steeply. It can be a point in the flyer's favour if, in the case of the take-off going wrong, they abandon it in a safe manner. It's far better that they think about what they are doing rather than try to coax a model with a sick engine into the air. If a take-off is aborted in a safe manner you should immediately reassure the candidate that they will not be penalised for taking correct actions, even though these may conflict with what the test requires.

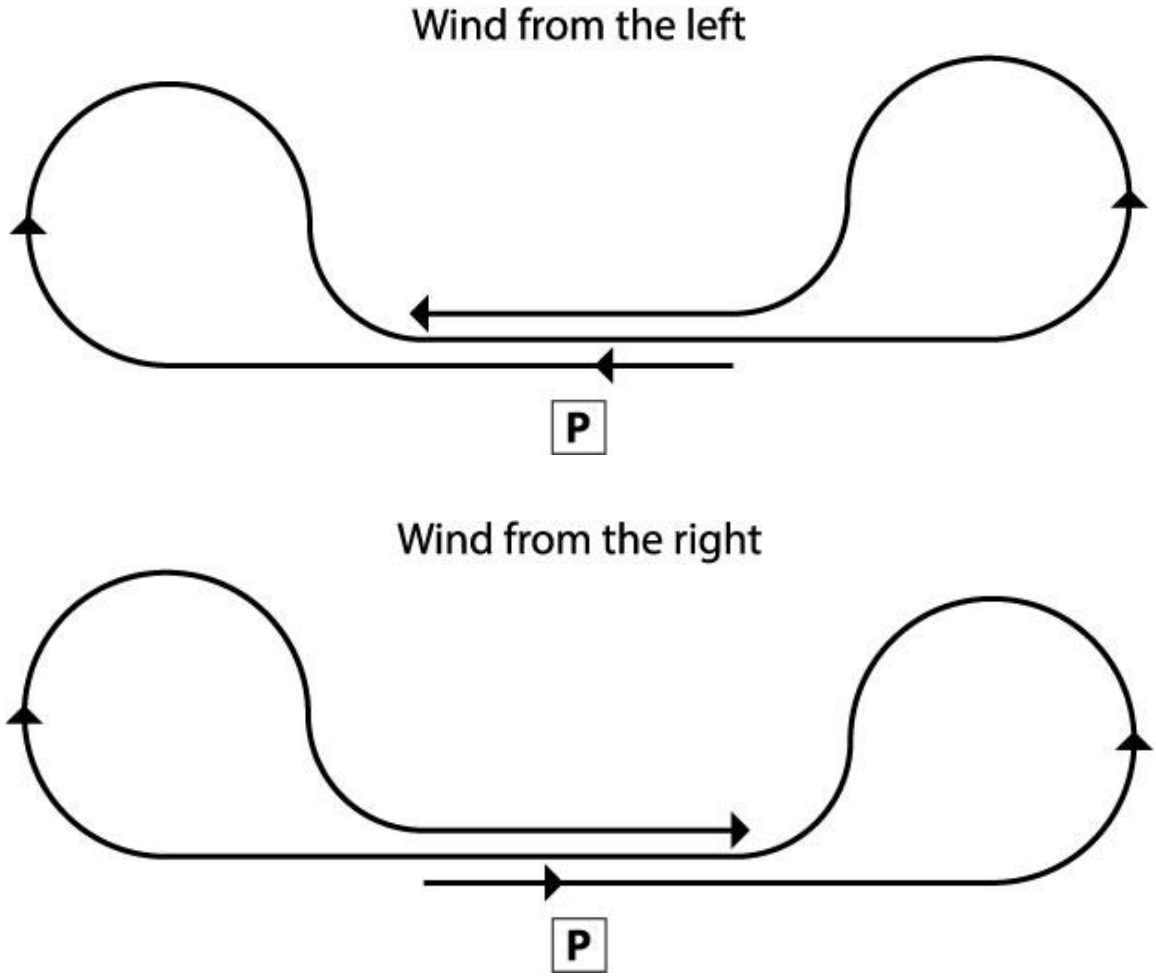
If the take off was conducted LOS, at some point during the climb out the pilot must convert to FPV flying. Climb out should be at a steady angle and straight until operational height is reached when the model should be levelled, the throttle brought back to cruise power and the model established in the circuit.

The type of circuit is not stated so either racetrack, rectangular or circular is acceptable. This choice of circuit type applies to the rest of the flight as well except when a certain type of circuit is specified for a manoeuvre.

On completion of the circuit, the model will be flying into wind past the front of the pilot and, for safety reasons, just over the far edge of the take off area. Tell the candidate prior to the flight the line that you want them to be following.

You must make sure that the candidate is clear on this as positional awareness is an important aspect of FPV flying. The line will be set by the model flying across in front of them on a heading which should be agreed before the flight (usually, but not always, into wind) and passing over a set point. This first pass in front of the pilot is extremely important as it sets the standard height and line for the rest of the test and this standard height and line will be referred to often in these notes.

**(c) Fly two reverse procedure turns, one to the left and one to the right, height to be constant.**




The candidate should be aiming to fly the manoeuvre as shown in one of the diagrams above, dependent on wind direction. For FPV flying the examiner should not expect the manoeuvre to be flown to the same degree of precision as one would expect for LOS flight. However, what is important is that the manoeuvre is flown at the correct distance from the pilot and examiner. Some latitude left or right is permissible, but no portion of the manoeuvre should bring the aircraft closer to the pilot box than the take off and landing area. The candidate should discuss and agree the positioning of this manoeuvre with the examiner prior to the test, taking into account any useful local visual reference points. The candidate may elect to use some form of additional visual marker, such as a cone or flag, to designate the centre of the far side of the landing area, in order to aid positioning during the test.

Before commencing this manoeuvre, the pilot must check with the competent observer that the airspace is clear and announce his intentions to any other pilots as parts of the manoeuvre will produce a flight path opposing the normal circuit direction.

The model is flown on the standard line and height into wind across the far side of the landing area. Once the model is a suitable distance past the landing area, the model is turned through ¾ circle away from the pilot. When the model is facing the flight line, it is then turned a ¼ circle in the opposite direction, to place it on a reciprocal heading to the entry. Once the model is downwind at a suitable distance past the landing area, the manoeuvre is repeated, as a mirror image, with the initial turn of the ¾ circle being away from the pilot. When the model is again facing the flight line, it is then turned a ¼ circle in the opposite direction, to place it on the

original heading into wind, at the approximate position where it started the two manoeuvres. Hence the manoeuvre finishes, as in the diagram, with the model flying into wind across the front of the pilot at standard line and height.

### (d) Fly a rectangular circuit at a constant height in the opposite direction to the circuit to be flown in (e) below.

Before commencing this manoeuvre, the pilot must check with the Competent Observer that the airspace is clear and announce his intentions to the other pilots, as the manoeuvre produces a flight path opposing the normal circuit direction. Any initial turn to position for this manoeuvre shall be away from the pilot box area.

Watch once again for parallel legs with reasonable turns and level flight. A common mistake is to turn on to the final crosswind leg (the upwind one) too soon. The result of this will almost inevitably be that the final turn of the manoeuvre will be too close to the pilot and may finish up as a 'panic' turn. Make sure that candidates give themselves plenty of room upwind, especially if the wind is at all strong.

### (e) Fly a rectangular circuit and approach with appropriate use of the throttle and perform a landing on the designated landing area.

The pilot should call this manoeuvre out loudly as a **LANDING** during the standard line and height initial into-wind pass across the landing area. The pilot should check with the competent observer that the landing area is clear before commencing the manoeuvre.

If a landing is called without this check then you may consider that the candidate has not given due consideration to field safety.

Watch out for the downwind leg not being flown parallel to the upwind leg and the turns being flown either too tight or too wide (most will try to fly them too tight and almost try to put a ninety degree 'snap' turn in which is **NOT** required). Throttle should be reduced either just before or just after the last crosswind turn with the crosswind leg descending into the turn on to final approach.

Once established on final approach, on line and descending, the candidate should make appropriate use of the throttle to set up and control the final descent rate. The aim of all this is to have the model at a speed, position and rate of descent which will guarantee a reasonably accurate touchdown on the landing area.

If the candidate opens the throttle and climbs away during the approach then they should have a very good reason, such as people walking out on to the runway. Any reasons offered by the candidate for an unscheduled overshoot **cannot** include not being lined up correctly or anything similar. However, if they do have good reason to perform an unscheduled overshoot and they handle the situation well then it would be fair for you to take this into consideration when summing up their flight.

If the test is taken with an electric powered model then you should be aware that ‘appropriate use of the throttle’ allows for different patterns of throttle use during the approach and landing and this will very much depend on the type of motor speed controller fitted to the model. With some controllers it is quite likely that the prop will be stopped at some points in the approach and also during the actual landing.

This is quite allowable but you must bear in mind that you are testing a rectangular circuit and power on landing so it is expected that the pattern flown by the model will equate closely with that which would be flown by a powered aircraft.

## (f) Remove model and equipment from the take-off/landing area.

The candidate should agree with the examiner beforehand whether they intend to take the transmitter with them when retrieving their model or choose to leave it with a competent person. The candidate must explain the safety considerations behind their decision, which must be agreed with the examiner. If the candidates elects not to take the transmitter and no one else is available to hold it then you should offer. Whatever process is agreed, it must also be in accordance with any relevant club rules, as appropriate. Generally, for 2.4GHz operations and with suitable consideration, candidates should be able to give a robust safety based argument for taking their Tx with them to recover the model, if it has landed on the normal landing/take-off area. Conversely, it is difficult to see how any such argument could be made for candidates using 35MHz or 27MHz equipment.

Remember that electric models must be assumed to be 'live' until the flight battery has been disconnected and the handling of the aircraft by the candidate must reflect this during retrieval and in the pits area.

## (g) Complete post-flight checks as required by the BMFA Safety Codes.

These are set out clearly in the handbook but you should watch particularly that the Rx off, Tx off, frequency system cleared sequence is followed correctly.

## The Questions

Having successfully completed the safety and flying elements of the test, the candidate must then answer correctly five mandatory questions based on legal compliance, as well as a **minimum** of five further supplementary questions on safety matters, based on the BMFA Safety Codes for General Flying and local flying rules etc.

Remember that on **no account** can a good performance on the questions make up for a flying test that you considered a failure. If you have failed the candidate's flying you should not even start to ask the questions. On the other hand the achievement scheme is a test of both flying ability and knowledge. It doesn't matter how well the candidate can fly, if they cannot answer the questions they should not pass.

**Mandatory Questions**

From April 2016 it is a requirement of all tests that candidates must answer correctly 5 questions taken from the list of mandatory questions based on legal aspects of model aircraft flying. (See Appendix 5) The examiner should only ask 5 questions and if the candidate does not know the answer to any question the test must be considered as a fail.

**The examiner must indicate on the test form which questions have been asked.**

It is expected that examiners will select questions that are appropriate to the test being taken, however candidates should familiarise themselves with all of the questions on the list. Candidates are not expected to be "word perfect" with their answers but they should be able to demonstrate that they are fully aware of the legal controls for model aircraft flying. For example if a candidate gives the answer to Question 4 (What does article 241 of the ANO state?) when asked Question 3 (What does article 240 of the ANO state?) it is likely they are aware of both answers and the examiner should point out they have answered the wrong question and ask for the correct answer.

**Supplementary Questions**

How many supplementary questions you should actually ask will depend on the circumstances at the time. For instance, if the candidate has done a good flying test and answers the first five questions with confidence then you need go no further. An acceptable test but with some rough edges can be offset to an extent by the candidate performing well in the first five questions.

A candidate who has done a test which you found only just acceptable and who hesitates on the questions should be asked a few more than five and if you are not satisfied that they have actually read the safety codes, you should not hesitate to fail them.

As an examiner, however, you should prepare yourself thoroughly for any testing that you do and you may wish to sort out your own personal and private list of sensible questions. Don't forget that you can use any local rules which you know and which the candidate should be aware of.

Remember that the majority of questions you ask are to be BASED on the BMFA Safety Codes; you are not expected to ask them 'parrot fashion' and the candidate is not expected to answer that way either.

This opens up the possibility of asking a candidate if they can think of reasons behind specific rules. For instance, why is the club frequency control system operated as it is and what might go wrong? There is always the possibility that the examiner may use the supplementary questions to further explore the candidates understanding of the mandatory questions.

## Administration

There are specific forms for Examiners to use during the FPV Extension tests, and if you do not have one then a call to the BMFA Leicester office will have some in the post to you by return.

Completed forms should be sent to the Leicester office within seven days of the test and, whilst they must be filled in by the Examiner, they may be sent in to the office by either the Examiner or the Candidate. You should take great care that all the details are filled in correctly, especially the successful candidates **NAME** and their **BMFA number** (this can save a great deal of confusion). If the candidate is not a BMFA member then it is especially important that you get their name and address correct and in full.

This is very important as what is seen on the pass form is what will appear on the final certificate. It is embarrassing for you to have to send one back to be re-done and it gives the candidate a definite impression of sloppy work by someone.

**Please note that the A4 Certificate(s) and updated membership card are not routinely sent directly to the individual tested.** However, the Leicester office will send the documents directly to the individual, upon direct and specific request from the Examiner concerned.

**Appendix 1**

## Examiners and Candidates FPV Extension Test Check List

The following is a short checklist of matters to discuss with the candidate taken from this document. This checklist can be used to ensure that all points raised above have been discussed with the pilot prior to any flights:

1 Has the candidate read: -

The BMFA handbook
Local site rules (if applicable)
'Safety Code for General Flying'
'Safety Code for FPV Flying'
and 'Operational Guide, All Models and Radio Control'. ☐

2 Discuss whether the model is suitable in "these conditions" ☐

3 Any "no fly zones" need to be identified ☐

4 Remind candidate to talk you through the role of the competent observer ☐

5 Agree any manoeuvre requirements that need to be pre-determined by the Examiner and Candidate prior to the commencement of the test flight ☐

6 Clearly identify the take off / landing point and agree with the candidate the appropriate flying area. ☐

**Appendix 2**

# FPV EXTENSION CERTIFICATE (Multi-rotor)

## Examiners Test Flight Check List

| Candidates Name | BMFA Number | Date | Examiner |
|---|---|---|---|
| | | | |

| | FLIGHT TASK | COMMENTS |
|---|---|---|
| (a) | Carry out pre-flight checks as required by the BMFA Safety Codes. | |
| (b) | Take off and hover forward for about five metres, stopping over the centre ground marker and hover briefly. Turn 90 degrees either left or right and fly forward to perform two 'lazy eights', each at least 30 metres in length. | |
| (c) | At the conclusion of the 'lazy eights', bring the multi-rotor to a halt above the centre ground marker, hover briefly, then fly to the original take off point, and land. | |
| (d) | Take off and climb to a safe altitude. | |
| (e) | Fly a left hand rectangular circuit | |
| (f) | Fly a right hand rectangular circuit | |
| (g) | After the conclusion of (g) the multi-rotor should descend smoothly to a position above the centre ground marker, hover briefly, then fly to the original take off point, and land. | |
| (h) | Complete post-flight checks as required by the BMFA Safety Codes. | |
| **Answer five questions from the list of mandatory questions on legal aspects of model aircraft flying.** | | |
| **Answer a minimum of five questions on safety matters from the BMFA Safety Codes and local flying rules.** | | |

**Appendix 3**

# FPV EXTENSION CERTIFICATE (Fixed Wing)

## Examiners Test Flight Check List

| Candidates Name | BMFA Number | Date | Examiners |
|---|---|---|---|
| | | | |

| | FLIGHT TASK | COMMENTS |
|---|---|---|
| (a) | Carry out pre-flight checks as required by the BMFA Safety Codes. | |
| (b) | Take off and complete a left (or right) hand circuit and overfly the take-off area. | |
| (c) | Fly two reverse procedure turns, one to the left and one to the right, height to be constant. | |
| (d) | Fly a rectangular circuit at a constant height in the opposite direction to the landing circuit flown in (e). | |
| (e) | Fly a rectangular circuit and approach with appropriate use of the throttle and perform a landing on the designated landing area. | |
| (f) | Remove model and equipment from take-off/landing area. | |
| (g) | Complete post-flight checks required by the BMFA Safety Codes. | |
| **Answer five questions from the list of mandatory questions on legal aspects of model aircraft flying.** | | |
| **Answer a minimum of five questions on safety matters from the BMFA Safety Codes and local flying rules.** | | |

## Appendix 4

### Mandatory Question List

**Q(1) Who Regulates all civil flying activities over the United Kingdom, including model aircraft ?**

A The Civil Aviation Authority

**Q(2) How are the rules and regulations for flying established in law by Parliament (statute) ?**

A As a series of Articles contained within in the Air Navigation Order (ANO).

**Q(3) What does Article 240 (previously 137) of the ANO state ?**

A 'A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft.'

**Q(4) What does Article 241 (previously 138) of the ANO state ?**

A 'A person must not recklessly or negligently cause or permit an aircraft to endanger any person or property.'

**Q(5) Who is legally responsible to ensure that a model is flown safely ?**

A The pilot in command

**Q (6) Which Civil Aviation Publication (CAP) relates specifically to the use of model aircraft, and for which specific purposes only ?**

A CAP 658, for sport and recreation purposes only

**Q(7) According to CAP 658, which model aircraft are required to have an operating failsafe and what is the minimum setting ?**

A
1) Any aircraft >7kg
2) Any Gas Turbine powered aircraft
3) Any powered model aircraft fitted with a receiver capable of operating in failsafe mode

As a minimum, reduce the engine(s) speed to idle on loss or corruption of signal.

**Q(8) What does Article 94 (previously 166) of the ANO say about the responsibilities of the person in charge of a small unmanned aircraft ?**

A The person in charge of a small unmanned aircraft may only fly the aircraft if reasonably satisfied that the flight can safely be made.

**Q(9) What does Article 94 (previously 166) of the ANO say about visual contact with small unmanned aircraft ?**

A The person in charge must maintain direct, unaided visual contact with the aircraft sufficient to monitor its flight path in relation to other aircraft, persons, vehicles, vessels and structures for the purpose of avoiding collisions.

**Q(10) What does Article 94 (previously 166) of the ANO say about small unmanned aircraft above 7kg ?**

A The person in charge of a small unmanned aircraft which has a mass of more than 7 kg must only fly the aircraft:
- Clear of controlled airspace unless with Air Traffic Control (ATC) permission.
- Clear of any Aerodrome Traffic Zone (ATZ) unless with ATC permission.
- At less than 400 ft above the point of launch except with permission as above.

**Q(11) What does Article 94 (previously 166) of the ANO say about 'aerial work' for small unmanned aircraft ?**

A The person in charge of a small unmanned aircraft must not fly the aircraft for the purposes of aerial work except in accordance with a permission granted by the CAA.

**Q(12) How is a flight for the purpose of 'aerial work' defined ?**

A Any flight for which 'valuable consideration' is given or promised in respect of the flight or the purpose of the flight. Essentially any gain you may make from the work undertaken.

**Q(13) How is 'a small unmanned surveillance aircraft' defined ?**

A An aircraft which is equipped to undertake any form of surveillance or data acquisition.(this includes all camera equipped aircraft)
NOTE: The provision of data solely for the use of monitoring the model is not considered to be applicable to the meaning of 'surveillance or data acquisition'.

**Q(14) What are the separation requirements of Article 95 (previously 167) - for small unmanned surveillance aircraft - when operating over or within a congested area or organised open-air assembly of more than 1,000 persons ?**

A The aircraft must not fly over or within 150 metres of a congested area or organised open-air assembly of more than 1,000 persons

**Q(15) What are the separation requirements of Article 95 (previously 167) - for small unmanned surveillance aircraft - in respect of any vessel, vehicle or structure which is not under the control of the person in charge of the aircraft ?**

A The aircraft must not fly within 50 metres of any vessel, vehicle or structure not under the control of the person in charge of the aircraft.

**Q(16) Except during take-off and landing, what are the separation requirements of Article 95 (previously 167) - for small unmanned surveillance aircraft – excluding the person in charge of the aircraft or anyone under their control ?**

A The aircraft must not fly within 50 metres of any person

**Q(17) What must be obtained before any flight within controlled airspace or an ATZ of an aircraft over 7kg?**

A Obtain permission from the appropriate air traffic control unit.

**Q(18) CAA General Exemption E 4049 - permits FPV flight without a buddy box, but with a competent observer. (a) How must the competent observer monitor the flight and (b) What is the maximum mass of aircraft that may be flown under this exemption?**

A • (a) The competent observer must maintain direct unaided visual contact with the model at all times
• (b) The aircraft must be below 3.5kg including batteries and fuel

**Q(19) Who has legal responsibility for the safety of an FPV flight a) conducted with a buddy box lead and b) conducted without a buddy box lead ?**

A • (a) The person in charge who must maintain direct unaided visual contact with the model at all times
• (b) The person piloting the aircraft (SUA)

**Q(20) According to CAP 658 what are the 8 'Only fly if' checks for an FPV flight of an aircraft over 3.5kg ?**

A • The activity is solely for 'sport and recreation' purposes;
• Two pilots take part;
• A Buddy Box system is employed;
• The person in charge operates the master transmitter;
• The person in charge does not wear the headset or view a screen;
• The aircraft remains within the natural unaided visual range of the person in charge;
• Reliable operation of the Buddy Box is established; and
• A clear handover protocol is established.

## Appendix 5

### Multi-rotor Types

Multi-rotors come in numerous variations, sizes and formats, not all of which will be suitable for the multi-rotor tests. Some use servos to tilt motors, but these should not be confused with tilt shift aircraft.

**Bi-rotor**
These have two motors only and two servos. Each motor is mounted on a servo-controlled pivot. **These are the least stable of the multi-rotors and are therefore not recommended to use for either test.**

**Tri-rotor / Tricopter**
As the name suggests these have 3 motors, typically spaced in a Y-shape, with the rear single motor being mounted on a servo-controlled pivot.

**Quad-rotor / Quadcopter**
These are likely to be the most common model used, using four motors and no servos. (This excludes variable pitch models mentioned further down this list) They can be safely flown in either a plus or cross format, this will boil down to what the individual pilot feels is easier to orientate and no preference should be given to either. There will be two motors spinning clockwise and two counter clockwise to overcome the torque effect. By slowing a pair of motors down and speeding up the other pair, the torque effect is used for yaw.

**Hex-rotor / Hexacopter**
With six motors, these can either have the motors spaced out evenly in a circle or doubled up in a Y-format. Again no servos are used for this format. Hex-rotors offer no more stability than a quad, but do offer an ability to keep flying in the event of a certain motor failures. These will have three motors spinning clockwise and three counter clockwise, when set up as a Y-shape, there will be one motor of each direction on each arm.

**Octo-rotor / Octocopter**
As per the hex-rotor, these can be set up with all motors in a circle, or set up with double motors as per the plus or cross quad-rotors. As with hex-rotors these offer more resistance to motor failures. These will have four motors spinning clockwise and four counters clockwise. When set up as a quad-rotor format there will be one motor of each direction on each arm.

**Variable Pitch Multi-rotors**
These can be any format from above, but are most typically done as quad-rotors as this tends to be the best balance between size and aerobatic performance. In the quad-rotor format a single motor drives four variable pitch rotors, which are intern controlled by servos. This variable pitch approach allows for a motor idle up being set and sustained inverted flight to be achieved.

**Reverse Direction Multi-rotors**
Another recent development has seen multi-rotors with reversible speed controllers / motors, this allows for sustained inverted flight as the motors reverse when inverted.

**Multi-rotor Flight Modes**

All multi-rotors will require a flight controller for operation, a device which contains a three axis gyro, much like a flybarless helicopter, but with the additional task of taking the radio control signals (Throttle, Aileron, Elevator and Rudder) and converting them in to motor or servo outputs. In order for a multi-rotor to fly, the flight controller will be making constant adjustments to all parts of the flight train, however it can also offer additional flight modes.

**It should be noted that multi-rotors of all formats and sizes could be fitted with none or all of the following flight modes as part of the main flight controller or in separate units.**

**Manual**
This is the only flight mode acceptable for use in the tests, as in this mode the multi-rotor is not self-stabilised. A continued aileron input for example will see the model continue to rotate around the aileron axis. An easy demonstration to request from the pilot to confirm this is the flight mode in use is to ask the pilot to apply a small aileron input and then release the stick to centre. The model should continue along the new aileron trajectory and not self-level, requiring opposite aileron input to stop the slide and return the model to level.

**Attitude / Stabilised Mode**
Often referred to as ATTI mode or STAB, this is the first of the auto pilot modes. In this mode the model will self-level when the sticks are centred and the model will simply drift with the wind if no input is given. In addition full aileron or elevator will only result in the model reaching a maximum tilt of 30-40 degrees and never tipping over.

**GPS Mode**
Occasionally referred to as Loiter Mode, the model uses GPS to lock its position via satellite. The model will often still accept flight control inputs and behave much like in ATTI Mode, however centering the sticks will see the model stop still in its position. In this mode the model will also resist external forces such as wind and make corrections to stay still. It is also possible with some GPS equipped models to set waypoints and send the model on its way completely autonomously or have the model ‘Return to Home’.

**Compass Mode**
Often also referred to as CAREFREE mode. This mode works by setting an artificial North. With the model facing in a set direction, entering compass mode will see the model travel along its new North from forward elevator input irrelevant of which way the model is now facing. Essentially this allows the model to be pirouetted while always travelling in the same direction from forward elevator input. It should be noted that the compass will typically take the front of the model as its new North when activated, so it is possible for forwards on the stick to become left, right or backwards, depending on which way the model was facing when activated.

**Altitude Mode**
Some models are also capable or maintaining their altitude.

**Multi-rotor Pre & Post Flight Checks**

**(A) Checks before daily flying session.**

1. Check that all rotor blades are in good condition with no damage and securely attached to the motors or blade grips.
2. Check for loose or missing nuts and bolts.
3. Check all ball links for slop and change as necessary.
4. Check there is no backlash in the drive system apart from gear backlash, which should not be excessive.
5. Check that servos are secure.
6. Check that the receiver aerial is secure and in good condition with no chafing or damage.
7. Check that the flight controller is secure and that all aerials including GPS are secure and orientated in the correct direction.
8. Check all transmitter switches are in the right positions.

**(B) Checks before and after each flight.**

1. If the multi-rotor suffers damage or a heavy landing, recheck all of (A) above.
2. Check all controls before starting especially for binding links or slowing servos.
3. Check for vibration and eliminate before flight.
4. Check that all wiring is secure and cannot become entangled with any moving or rotating part, especially the receiver aerial.
5. Before starting insure all switches are in the correct position for takeoff and the correct flight mode selected before **EVERY** flight.
6. If planning to use GPS at any point during the flight, confirm that you have a suitable lock before taking off. (Method for this will vary from unit to unit, but is typically by way of a flashing indication LED)
7. Are the multi-rotors arms secure, especially in the case of collapsible or folding air frames.

**Multi-rotor Additional Safety Considerations**

**The following is a list of additional scenarios that multi-rotors can create, but is in addition to standard procedures for electric or I/C models and general safe flying practices. Due to the fast changing nature of multi-rotors this list should not be considered definitive.**

Different multi-rotors will use a vast selection of propellers from soft plastic, through wood and up to carbon. In all cases the propeller should be suitable for the type and power output of each motor and metal propellers must never be used.

Many multi-rotors use the frame as a power distribution board, it is important to insure that all wires are secure and that there is no risk of short-circuiting. Multi-rotors can create more RF interference than the average model aircraft and although the use of ferrite rings might not be necessary with 2.4Ghz radios it is advised to carefully consider the positioning of any and all aerials and wiring.

Multi-rotors are predominantly electric, so all standard controls of electric models should be applied, especially the consideration that the model is live the moment it is connected. As a result models should not be connected in pits areas or car parks.

Models with GPS can typically be programmed to follow waypoints, at no point may the craft become fully autonomous, in other words the pilot should be in control as all times and capable of taking control and overriding any pre-programmed flight commands with the transmitter. The same applies to the use of the 'Return to Home' feature.

Models using Waypoints or Return to Home must consider the flight path of the model and insure no obstacles will interfere with the model, as this type of flight is often 'As the crow flies'.

Careful consideration must be taken with models with GPS and 'Return to Home' features as to where they are connected and or started, as this is often the 'Return to Home location' and must be set as a safe area, e.g. a safe distance in to the runway and not the pits or car park.

It is not easy to safely restrain a multi-rotor so when testing the failsafe it is necessary to remove the propellers.

GPS is typically very good at holding a model to within inches of its position, but is only truly accurate to within 5m of latitude, longitude and altitude.

GPS can take time to 'find itself', especially on the first initialization of the day, so time should be given to achieve a safe and stable lock before **EVERY** flight.

A descending multi-rotor is flying through its own prop wash and will often 'wobble' as it descends. Trying to descend too fast can cause a model to suffer too much wobble creating a tip stall. A great method to avoid excessive wobble is to descend while travelling, e.g. a 45deg descent.

A multi-rotor with too much gyro gain will oscillate in the air, where as too little will create a model that rocks or drifts excessively.

A multi-rotor that appears to "toilet bowl" (drifting around in a circle) is typically searching for a GPS lock.

Models with GPS that are armed too quickly can shoot off trying to return to their last known

GPS position. This again refers to arming and flying before GPS is fully engaged.

**Pre-test considerations / checks for examiners.**

The following is a guide for examiners to assess that a pilot truly understands the aircraft they are flying and the modes it operates in.

**Flight modes:**

As mentioned in the earlier section of this document, multi-rotors can have numerous flight modes. The pilot being tested should be able to clearly explain what each mode is on their model and what switch it is assigned to. They should also be able to explain how the model will react in each mode and any special considerations that should be made for each mode. Again, you can refer back to the earlier section on flight modes for reference, but here are some key things to consider for each mode that the pilot should understand.

**Things that need to be considered for each mode:**

**GPS:**

GPS does not work instantly when a model is armed and may take time to arm, especially on the first flight. All GPS equipped models will have a warning LED indicating the GPS Status, i.e. is it locked, how many satellites it's reading etc. Also many will not work indoors, under trees or near power lines. Failing to wait for a successful GPS lock can result in a model struggling to hold location or even a fly away. GPS units typically have an orientation and a pilot should be able to demonstrate that is in the right position/angle.

**RTH – Return To Home:**

A pilot using RTH should understand exactly when the model sets its home position. In some cases this is as soon as the battery is plugged in, whereas on others it is when the model is first armed for flight. In either case, the pilot should explain this for their model and arm the model in line with this.

If equipped with RTH the pilot should be able to explain what will happen in this mode. Many models will stop where they are, gain height, then fly in a straight line as the crow flies to their RTH point before then entering a slow decent to landing. Others may simply fly back at the altitude they are starting at and some may then only loiter at a set height once reaching the RTH point and not land.

The pilot should also understand the legal implications of RTH. At this moment in time, RTH is not a legal option for failsafe (This is currently being discussed with the CAA and may change). RTH can only be used as a controlled mode of flight, i.e. the pilot can deliberately put the model in a RTH state, but then instantly regain control at any time. RTH is not legal if the model decides to enter RTH mode on its own due to say loss of signal or low battery, or if the pilot cannot re-take control once RTH's is initiated.

**Compass Mode / Carefree Mode:**

Carefree mode as mentioned earlier sets an artificial north for the model. The pilot should mainly be aware of the risk of setting an unusual or uncomfortable attitude for this mode. I.e. setting the mode while flying towards yourself will result in a model being set in a permanent 'nose-in' attitude. The pilot should be able to explain how to either exit this mode to normal flight or what they would do if this was accidentally set in flight.

**Attitude / Stabilised Mode**
This is mostly an idiot proof mode, however some of the earlier control units required the model to be positioned horizontally at point of arming to set the level point, i.e. arming with the model at 20deg will see the model always wanting to level to that angle in flight. As with many gyros devices, many control units don't like to be moved during the initial arming.

**Gain adjustment.**
Even a basic board that is only capable of manual flight mode can still have a switch assigned to adjust the gyro gains, essentially like a helicopter tail gyro having heading hold and rate mode. On a multi-rotor the behaviour difference between the two could best be described as high and low rates. With the gyro gain high the multi will be more docile / sluggish, where as with the gain dialled down it will be twitchy and able to rotate faster. A pilot should be willing to demonstrate to an examiner that both modes are still manual mode and that the 'low rate' mode is not in fact self-levelling.

**Motor Arming:**
Many control units have a safe mode, where the motors will not react to control inputs, requiring the transmitter to first use some set positions. For example this might be throttle down and full right rudder to arm, with throttle down and full rudder left to disarm.

**Failsafe:**
Multi-rotors are capable of various levels of failsafe, from the basic motors to idle minimum, to automatic flight modes. Such self flight modes are; **auto land**, where the multi-rotor self stabilises and goes in to a slow decent and **RTH** (return to home), in this mode the multi-rotor will typically climb by a set amount, turn and fly straight home to its initial arming point and land. Consideration should be taken in RTH mode as the craft typically flies in a straight line, so any obstacles in between such as trees or people may be hit.

**Examination question suggestions:**

**Flight mode:** The pilot should be able to explain all their flight modes and how the aircraft will behave in each mode.

**Failsafe settings:** The pilot should be able to explain what will happen on loss of signal, i.e., standard motors to idle or slow decent or return to home. This can also be linked to switches.

**Arming sequence:** Most multi-rotors have a set stick/switch position to start or stop motors.

**Switches:** The pilot should be able to clearly explain what flight modes are assigned to each switch.

**Specific craft considerations:** A pilot should be aware of specific behaviours relevant to their multi-rotor. I.e. a motor failure on a bicopter, tricopter or quad will result in a crash, however on a hexacopter or octocopter the model will typically begin to pirouette, but still fly.

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