Annex D

Basic Multirotor (MR) and Advanced Multirotor (AM)

General

The Wings Scheme is run by the MFNZ as a National Scheme and it is open to all members.

The examination for a Basic Certificate may be taken on application to any Registered Examiner. The examination for an Advanced certificate may be carried out by any Registered examiner holding a MR Wings qualification.

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.

The Basic Certificate

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

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 unsupervised'.

The candidate should have studied the MFNZ members manual, any local site rules (if applicable. 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 members manual.

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.

The Advanced Certificate

The Advanced Certificate is “designed to recognise the pilot's more advanced ability and a demonstrated level of safety. As an Examiner, therefore, the level of competence required from a candidate should be based on the question; 'has this person demonstrated their flying ability and safety to me in a satisfactory manner.

The aim of the Advanced certificate has always been to give the club flyer a personal attainment goal beyond the Basic Certificate; a demonstrated level of competence and safety which is attainable by the average pilot with a little thought and practice.

The long-term strategy behind this is that if enough club flyers qualify for their Advanced certificates then the general standard of flying both within your club and nationally cannot help but rise.

A candidate wishing to take the Advanced must already have passed the Basic in that discipline.

However, where a candidate presents for an Advanced test who does not already hold an Basic certificate it is acceptable for the candidate to complete the flying portion of the Basic test successfully and then move immediately to the flying portion of the Advanced test before attempting the test questions.

Note that the Basic flying test does not finish until the model has been retrieved and the post flight checks have been completed

The candidate for the Advanced should have studied the MFNZ members manual.

The Model

The tests can be performed with virtually any model multi-rotor, fixed pitch or collective.
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.

Gyros, Electronic Stabilisation and GPS

It is acceptable to use an electro-mechanical or solid state gyro/s in a multi-rotor being used to take the test although electronic stabilisation is restricted to enabling flight, at no point should the stabilisation effect take over control from the pilot or achieve automated or self-levelled flight. This allows a range of gyros to be fitted, from simple yaw dampers to solid state heading lock units.

The use of any autopilot and/or artificial stability features which are (or may be) designed into such units beyond definition above is not acceptable during the test for the Advanced and Basic certificates and is not permitted.

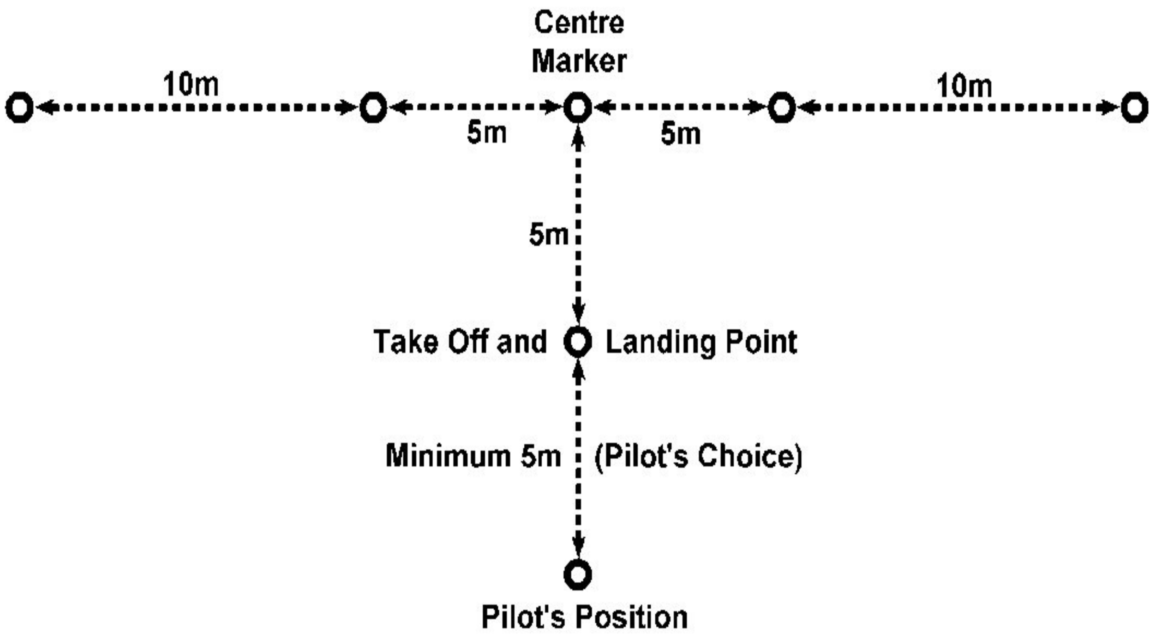
Candidates should be prepared to explain the capabilities of the system they are using and show that it does not take over control from the pilot and that automated flight will not be achieved during the test.

GPS must not be used during any test.

Ground Positioning

When taking a multi-rotor 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 or any other similar marker may be used if 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 take-off/landing point and the pilot's position must be used with some accuracy.

Landings should generally be no more than a metre from the take-off/landing point and the pilot is expected to stay close to the selected pilot's position mark although it is not required that they ‘plant’ their feet. If you feel that the pilot is starting to wander, you should stop them and insist that they stand near the pre-selected mark.

Remember that it is a requirement that ‘all manoeuvres are carried out in front of the pilot’ so the use of the pilot’s position point will be important.

General Manoeuvres and Hovering

All take-offs and landings should be smooth, without undue oscillations, and lifts and descents should be straight and controlled with the model a comfortable and safe distance in front of the pilot. 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 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 the fitting of a freshly charged flight battery. This landing may only be made with the prior consent of the Examiners. 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 Examiners.

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

The Basic Test

(a) Carry out pre-flight checks as required by the MFNZ Safety Codes and MFNZ Multi-Rotor Certification Appendix document. See appendix 1.

The pre-flight checks are laid out clearly in the MFNZ Multi-Rotor Certification Appendix document. The candidate should also go through the pre-flying session checks, laid out in the MFNZ members manual. 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 Basic certificate 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 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.
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.

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.

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.

(b), (c), (d), (e), (f) and (g) together form a horizontal 'T'.

During manoeuvres (b), (c), (d), (e), (f) and (g) the model should not have deviated significantly from a straight line drawn between the end points Slight drifting may be permissible in adverse wind conditions, but should be rapidly corrected and put back on the correct course. If the deviation is severe, or the model does not follow the line at all, the candidate should not pass. The hovering speed between the end points is at the discretion of the candidate but must be no faster than a slow 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, other than in (b).

The height of the multi-rotor should be consistent throughout these manoeuvres with no major deviations.

(b) Take off and hover over the take-off point, with the multi-rotor at approximately 10 feet, for about twenty seconds and then land.

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.

(c) Take off and hover for about five seconds, then hover the multi-rotor slowly forwards for approximately five metres, stop, and hover for about five seconds.

After the take off and five seconds' hover time and, on your command, the pilot now hovers the model forward, at a slow hovering pace, for about five metres then stopping and hovering for about five seconds. All the previous comments about line, height at approximately 10 feet, speed and steadiness apply and the orientation of the model should still be facing in the same direction as this initial forward hover, as for all the rest of the first set of manoeuvres.

(d) Hover the multi-rotor slowly sideways for approximately five metres, stop, and hover for about five seconds.

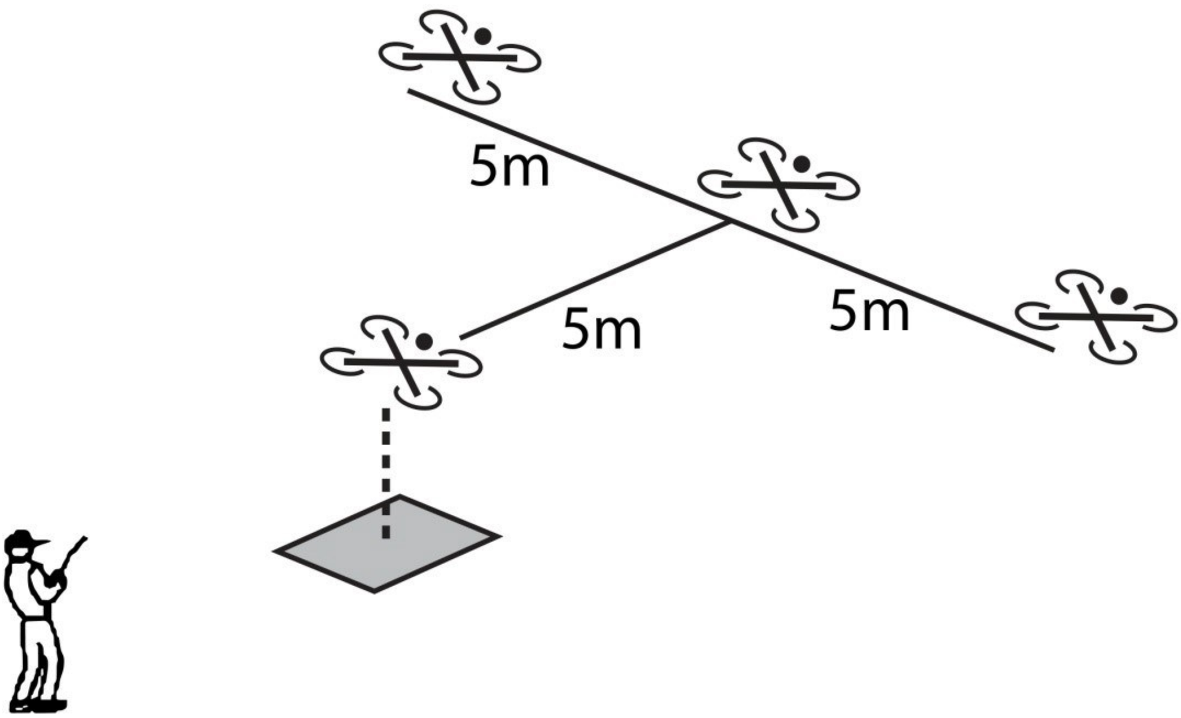
The pilot may choose to perform the initial sideways hover in either direction (to his left or right) and, once you have been told the direction, the candidate should, without turning the model, commence a sideways hover at a height of approximately 10 feet for approximately five metres. Having travelled about five metres the pilot will stop the model and hold it in a steady hover at 10 feet and, with the rear of the model pointing in the same direction as it was when it took off, for about five seconds

(e) Hover the multi-rotor slowly sideways in the opposite direction for approximately ten metres (five metres past its original position in front of the pilot), stop, and hover for about five seconds.

At the end of the hover time the pilot, without turning the model, will hover it sideways in the opposite direction, passing in front of them and stopping 5 metres past the centre line. At this point the pilot will once again stop and hover the model with it still facing in the same direction as it was at take-off.

(f) Hover the multi-rotor slowly sideways in the first direction to bring it back to its original position in front of the pilot, stop, and hover for about five seconds.

The candidate should, without turning the model, commence a sideways hover at approximately 10 feet for approximately five metres back to the centre marker. Having travelled to the centre marker the pilot will stop the model and hold it in a steady hover for about five seconds at approximately 10 feet and, with the rear of the model pointing in the same direction as it was when it took off.



(g) Fly slowly backwards, bringing the multi-rotor back to its original position over the take off point, stop, hover for about five seconds and land.

After hovering for about five seconds, the model is hovered backwards (without turning it) to the start position, stopped and hovered for about five seconds above the TOLP with skids at approximately 10 feet. After the hover time, has been completed the model should descend and land close to the original take off point. During this last section, you will be observing the same criteria as previously and the model should have performed as before in relation to the course and at a similar speed. The descent and landing should be smooth and steady with little bouncing on landing, caused by not being level or poor throttle control.

(h) Take off and fly slowly forward for approximately 5 metres, stop and hover for about five seconds. Turn 90 degrees either left or right and fly forward to perform two 'lazy eights', each at least 30 metres in length. Each time the multi-rotor passes in front of the pilot it must be sideways on to the pilot and throughout the manoeuvre the model must be flying forward, not sideways.

The pilot should make a quick visual check that the area he intends to overfly is clear and that no other models are flying in the near vicinity; you should be watching for definite head movements as they scan the area.

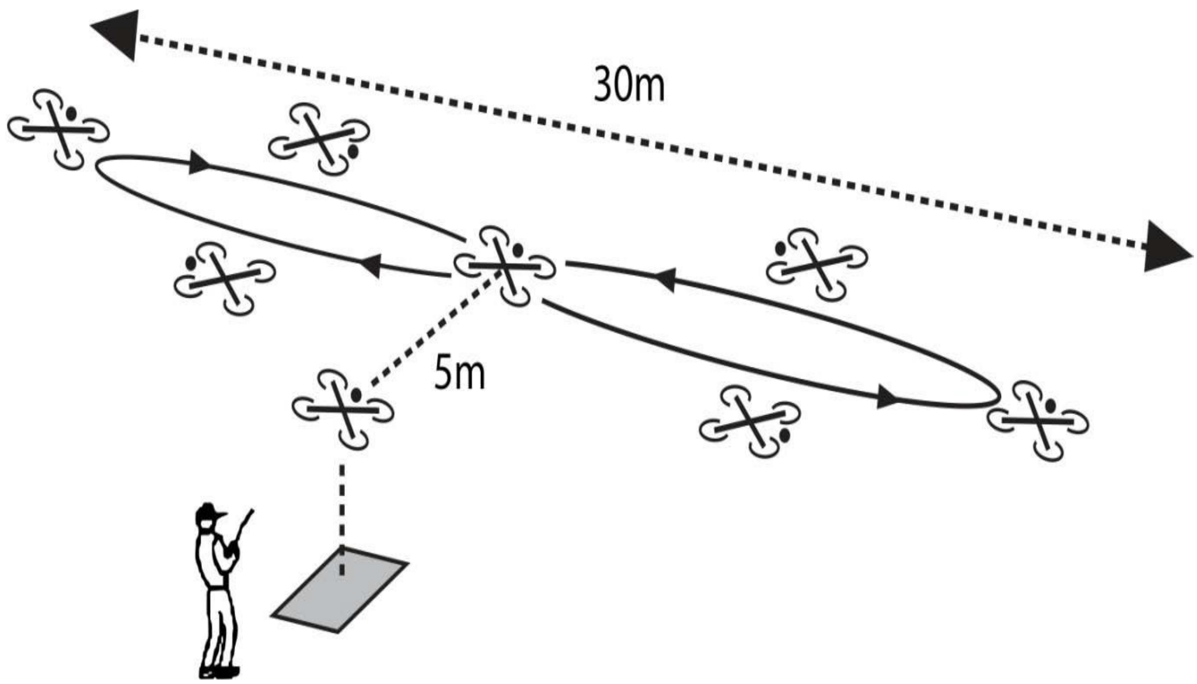
The pilot should fly this manoeuvre at a safe height above eye level, but should not fly at such a height that the model cannot be clearly seen by both the pilot and yourself. Between three and five metres is the correct height band for this part of the test and the model **must** hover through the lazy eights, not fly through 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, stopping over the centre marker and hovering for about five seconds.

The pilot then turns the model 90°, either left or right and, at the same time, slowly moves off forward at about a **walking pace** (but still in the hover). It is not required that the 90° 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.

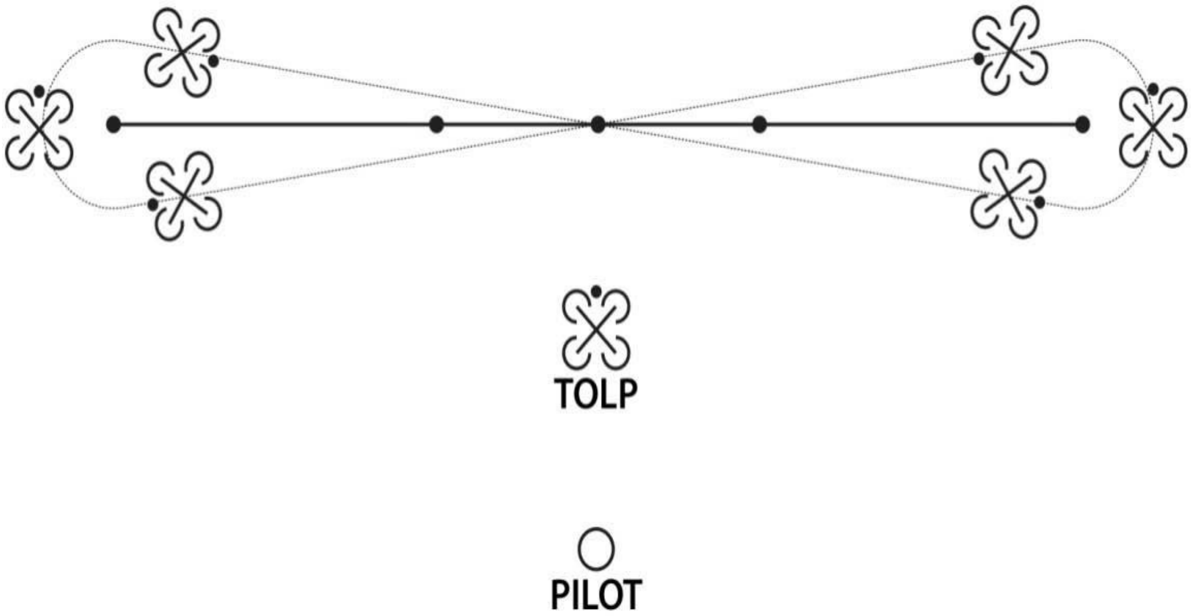
The pilot moves away at his chosen height for about fifteen metres where they begin a turn the model smoothly through 180°, flying forward in the hover all the time, and bringing the model back across in front of them. Without hesitation, the model continues at the same speed in the new direction until 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 hovering 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 hover 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.



At no time during the manoeuvre should the model be flying sideways. Throughout all the turns and straight flight, it must be flying forward in the hover and not 'crabbing' sideways.

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 the diagram in the MFNZ Multi-Rotor Certification Appendix document and 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 high degree of control can be demanded.

(i) After the two 'lazy eights', bring the multi-rotor to a halt sideways on over the centre marker. Turn the model until the rear of the model is facing the pilot and hover for about five seconds. From this point fly the model to a landing on the original take off point.

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 stop in front of and sideways on to himself. The model is then turned to the heading it had before the lazy eights were started and hovered for about five seconds. At this point it should be over the centre marker, about five metres in front of the TOLP and hovering at the standard height.

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 engine/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.

(j) Complete post flight checks as required by the MFNZ Safety Codes.

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

The Advanced Test

(a) Carry out pre-flight checks as required by the MFNZ Safety Codes and MFNZ Multi-Rotor Certification Appendix document.

The pre-flight checks are laid out clearly in the MFNZ Multi-Rotor Certification Appendix document. The candidate should also go through the pre-flying session checks, laid out in the MFNZ members manual. 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 multi-rotor for flight.

A tidy flight box and a neat ground layout makes a good impression and is to be expected from Advanced certificate candidates

A poor performance in this area is not direct grounds for failing the candidate but it is inevitable that you will be making mental notes of all aspects of the candidate's performance and this is one that may influence a real 'borderline' case.

Pay 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.

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.

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.

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 pad, etc., but any such actions must only 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 your pre-flight briefing.

(b) Perform one hovering bow tie

All sections of the manoeuvre are numbered and referenced to the manoeuvre drawing. The manoeuvre as described is flown anti-clockwise. However, the direction of the flight may be either clockwise or anti-clockwise, at the discretion of the Examiner.

At all times in the manoeuvre, the model must be facing forward.

(1) The model starts on the TOLP, takes off and flies to a position over the centre marker where it is hovered for about 5 seconds.

(2) The model then hovers sideways to the left for about 5 metres to a position over the left inner marker where it is held and hovered for about 5 seconds.

(3) The model then hovers backwards for about 5 metres to a position immediately behind the left inner marker and level with the TOLP where it is held and hovered for about 5 seconds.

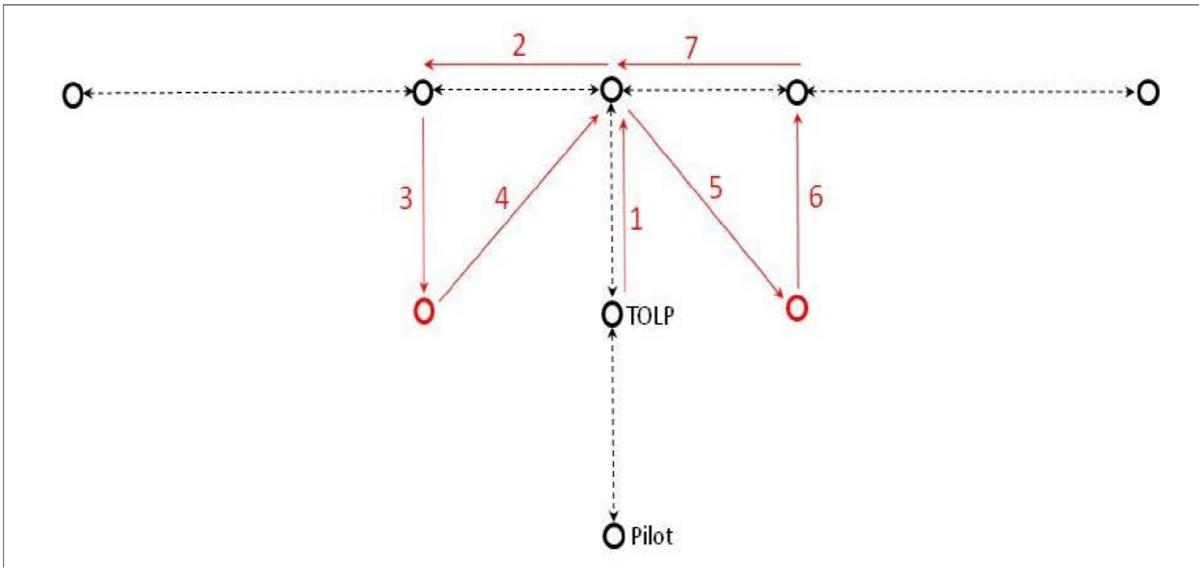
(4) The model then hovers diagonally forward and to the right to a position over the centre marker where it is held and hovered for about 5 seconds.

(5) The model then hovers diagonally backward and to the right to a position immediately behind the right inner marker and level with the TOLP where it is held and hovered for about 5 seconds.

(6) The model then hovers forwards for about 5 metres to a position over the right inner marker where it is held and hovered for about 5 seconds.

(7) The model then hovers sideways to the left for about 5 metres to a position over the centre marker where it is held and hovered for about 5 seconds.

This completes the manoeuvre.



Hover height must be consistent throughout the manoeuvre and there should be minimum wandering away from the straight lines between the designated hovering points as the manoeuvre is flown.

(c) Perform one 4-point pirouette

From the previous manoeuvre, the manoeuvre is begun with the multi-rotor hovering over the centre marker, with the rear or the model facing the pilot and it is held in that position for about 5 seconds. The model is then rotated 90 degrees and held in the hover, sideways on to the pilot for about 5 seconds.

The model is then rotated a further 90 degrees in the same direction to have the front of the model facing the pilot and hovered in that position for about 5 seconds.

The model is then rotated a further 90 degrees in the same direction to the sideways on position to the pilot and hovered in that position for about 5 seconds

The model is then rotated a further 90 degrees in the same direction to the starting position, with the rear of the model facing the pilot and hovered in that position for about 5 seconds.

The model is then hovered backwards for approximately 5 metres and landed on the TOLP.

This completes the manoeuvre.

The multi-rotor must rotate either clockwise or anti–clockwise for the entire manoeuvre. The Examiner will state which direction he wishes to see. The clear inference is that the candidate must be competent to perform the rotations in both directions prior to the test.
Hover height must be consistent throughout the manoeuvre with minimum wandering away from the Centre marker. The landing must be within the 2 metre diameter circle centred on the TOLP.

(d) Perform one 'Top Hat'

The pilot should now take off and hover the model at a height of approximately 10 feet to a position either hovering over the appropriate outer marker or approaching it at hovering pace along the line of the cross markers.

The model now moves forward at the normal hovering pace for ten metres, stops and hovers for about five seconds then climbs vertically for four metres before hovering again for about five seconds. The pilot will now hover the model forward for ten metres so that the model passes the pilot sideways on to them.

The model again hovers for about five seconds and the pilot now causes the model to descend four metres until the model is once again at a height of approximately 10 feet where it again hovers for about five seconds. The model now moves forward for another ten metres and passes over the opposite end outer marker which concludes the manoeuvre.

The model, still at approximately 10 feet, must then be hovered back to the take-off/landing point and landed smoothly and steadily.

The speed during the top hat should approximate to a normal walking pace, and the heading is constant throughout. The entry and exit to the manoeuvre is a test of the pilot's ability to correctly position the model. The model should not drift away from or toward the pilot significantly and the model should be under accurate control for the whole manoeuvre.

The manoeuvre may be flown either from left to right or from right to left and the direction is decided by the Examiner.

(e) Take off and climb to a safe altitude.

The pilot must ensure that the route of his proposed flight path is clear before taking-off; watch for head movement as they scan the area. On taking-off, the multi-rotor will lift to a brief hover at about half a metre high. After again checking for obstacles and obstructions the pilot then climbs out at an angle greater than 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. the pilot will also be looking for other traffic along the intended route.

(f) Fly a left hand rectangular circuit.

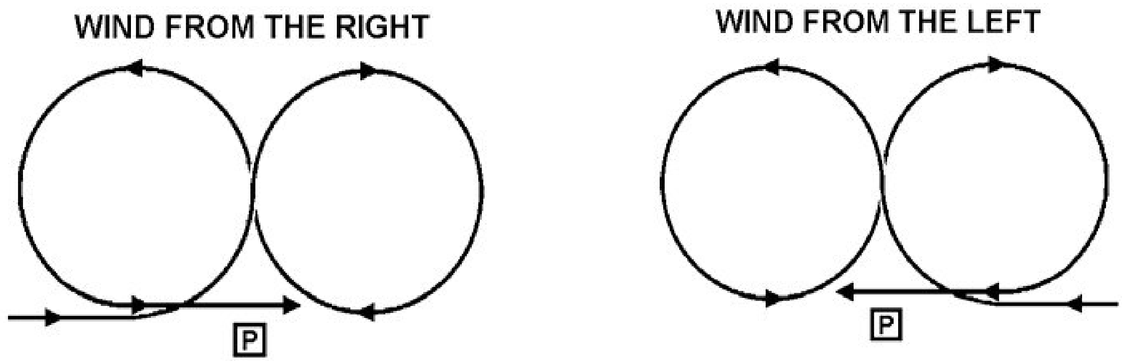
(g) Fly a right hand rectangular circuit.

The pilot can elect to fly these manoeuvres in either order. The circuits should be rectangular as shown in the manoeuvre diagrams. 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 pad. Tell the candidate prior to the flight the line you wish them to follow.

You must ensure that the candidate is clear on this, the line will be set by the model flying in front of them on a heading which will be agreed before the flight (and this will not always be into wind), and passing over a set point. The first pass in front of the pilot is extremely important as it sets the standard height and line for the rest of the 'flying' manoeuvres.

(h) Fly a Figure of Eight at circuit height with crossover in front of the pilot



This should be flown as a banked circuit manoeuvre (not from the hover) and as shown in the diagram. The crossover point must always be in front of the pilot and, after a run in at standard height and line, the model MUST be turned through ninety degrees in the first turn so that it is flying exactly away from the pilot.

The first circle must also end with the model flying exactly away from the pilot, through the crossover point before it is turned into the second circle. Both circles should be of the same diameter as seen from the ground.

The main problems with this manoeuvre nearly always happen on the circle that is upwind of the pilot and if they do not adjust the angle of bank/turn rate to compensate they will either miss the crossover point by being a good way downwind, fly too near the pilot's line, fly circles that are distorted or panic as the model accelerates towards them as it begins to come downwind and pull far too much bank (vertical!) to get the crossover point correct. This is not a sign that they have thought about the manoeuvre or practised it.

The second circle (3/4 circle) is rarely a problem. The manoeuvre finishes with the model flying at standard height and line across the front of the pilot, not with another turn away. The initial run-in to the manoeuvre may be either from left to right or from right to left and the direction is decided by the Examiner.

(i) Perform one twenty second nose-in hover.

The model must now transition from forward flight to the hover in a safe and steady manner and position for the nose-in hover, where the model is hovered with the front facing the pilot.

The pilot should position the model over the centre marker, hovering at a height of approximately 10 feet. After a brief hover, the model is turned so that the front is towards the pilot and held steadily in the nose-in hover for at least 20 seconds, then turned back, climbed away and transitioned to forward flight.

If the model is not completely nose in you should ask the pilot to correct its position before starting the twenty second count. The multi-rotor should not drift significantly in any direction and height control should be good.

(j) Perform one loop.

The model should be flown out to a point between 30-50 metres past the pilot, then flown back past the pilot on standard height and line, at the point the model reaches in front of the pilot a loop of approximately 15-25 metres diameter should be performed. A perfect loop is not required but the exit height and line should be very close to the original.

Skewing out is a sign that the model has not been trimmed correctly or that the model was not level at the start of the manoeuvre. The pilot should not get into this situation to start with but if they do then they must be able to compensate; if they cannot then you must draw your own conclusions. Throttle is typically required always for a multi-rotor to manoeuvre, but watch that the throttle is controlled during the manoeuvre and penalise the pilot if they fly the manoeuvre at a constant high throttle setting.

The initial run-in to the manoeuvre may be flown either from left to right or from right to left and the direction is decided by the Examiner.

N.B. See Appendix 5 for guidance on completing this manoeuvre.

(k) Perform an approach at 45° to the vertical, landing within a pre-determined two metre square.

It is difficult to judge the angle of descent unless the model is almost sideways on to the pilot. For this reason, the pilot should consider the planned approach path carefully and agree it with the Examiner during the pre-flight briefing. The direction of approach is the pilot's decision and everyone concerned with the test should be very clear exactly how the pilot will be attempting to fly the manoeuvre.

It is not a requirement that this manoeuvre should be entered from full forward flight so the pilot may set up the model in a steady hover or be moving forward in steady hovering flight at a minimum height of fifteen metres and at an appropriate distance away from the TOLP. The model should then sink at a constant rate with constant forward movement at an angle near to 45_o, heading down towards the TOLP. Finishing this descent exactly over the TOLP is not required but the model should be no more than a metre or so out. The candidate is allowed a short hover at a height of around half a metre to make minor corrections before settling the model on the ground.

The landing should be made with the model on the same heading as on the 45^0 descent.

After landing, the candidate should shut down the engine and allow the rotor blades to stop turning before collecting the model to return to the pits.

(l) Complete post flight checks as required by the MFNZ Safety Codes.

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

Appendix 1 Examiners and Candidates Basic 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 MFNZ members manual
Local site rules (if applicable) Safety Code for General Flying ☐

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 anything that the helper may do for them as the test progresses ☐

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

6 Clearly identify the take-off / landing point and agree with the candidate the required hovering times that he will be flying and you will be being looking for. ☐

Appendix 2 Examiners and Candidates Advanced 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 MFNZ members manual
Local site rules (if applicable)
Safety Code for General Flying
Operational Guide, All Models and Radio Control
Code of Practice for Model Flying Displays ☐

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 anything that the helper does for them as the test progresses ☐

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

6 Discuss the various manoeuvres and any options that may be available so that there can be no misunderstanding during the test ☐

7 Does the candidate understand how you expect to see the model positioned about the wind throughout the test? ☐

8 Clearly identify the landing area and agree with the candidate the required landing pattern that he will be flying and you will be looking for. ☐

Appendix 3

Basic CERTIFICATE (MULTIROTOR) MR Examiners Test Flight Check List

Candidates Name	MFNZ Number	Date	Signature
Examiner's Name	**MFNZ Number**	**Date**	**Signature**

	FLIGHT TASK	COMMENTS
(a)	Carry out pre-flight checks as required by the MFNZ Safety Codes.	
(b)	Take off and hover tail in over the take off point, with the multi-rotor at 10 feet, for about twenty seconds and then land.	
(c)	Take off and hover for about five seconds then hover the multi-rotor slowly forwards for approximately five metres, stop, and hover for about five seconds.	
(d)	Hover the multi-rotor slowly sideways for approximately five metres, stop, and hover for about five seconds	
(e)	Hover the multi-rotor slowly sideways in the opposite direction for approximately ten metres (five metres past its original position in front of the pilot), stop, and hover for about five seconds.	
(f)	Hover the multi-rotor slowly sideways in the first direction to bring it back to its original position in front of the pilot, stop, and hover for about five seconds.	
(g)	Fly slowly backwards, bringing the multi-rotor back to its original position over the take off point, stop, hover for about five seconds and land	
(h)	Take off and hover forward for about five metres, stopping over the centre ground marker and hover for about five seconds. Turn 90 degrees either left or right and fly forward to perform two 'lazy eights', each at least 30 metres in length. Each time the multi-rotor passes in front of the pilot it must be sideways on to the pilot and throughout the manoeuvre the model must be flying forward, not sideways.	
(i)	At the conclusion of the 'lazy eights', bring the multi-rotor to a halt above the centre ground marker, turn the model tail in to the pilot and hover for about five seconds. Then fly to the original take off point, and land.	

(j)	Complete post-flight checks as required by the MFNZ 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 MFNZ Safety Codes and local flying rules.		

Appendix 4

Advanced CERTIFICATE (MULTIROTOR) AM Examiners Test Flight Check List

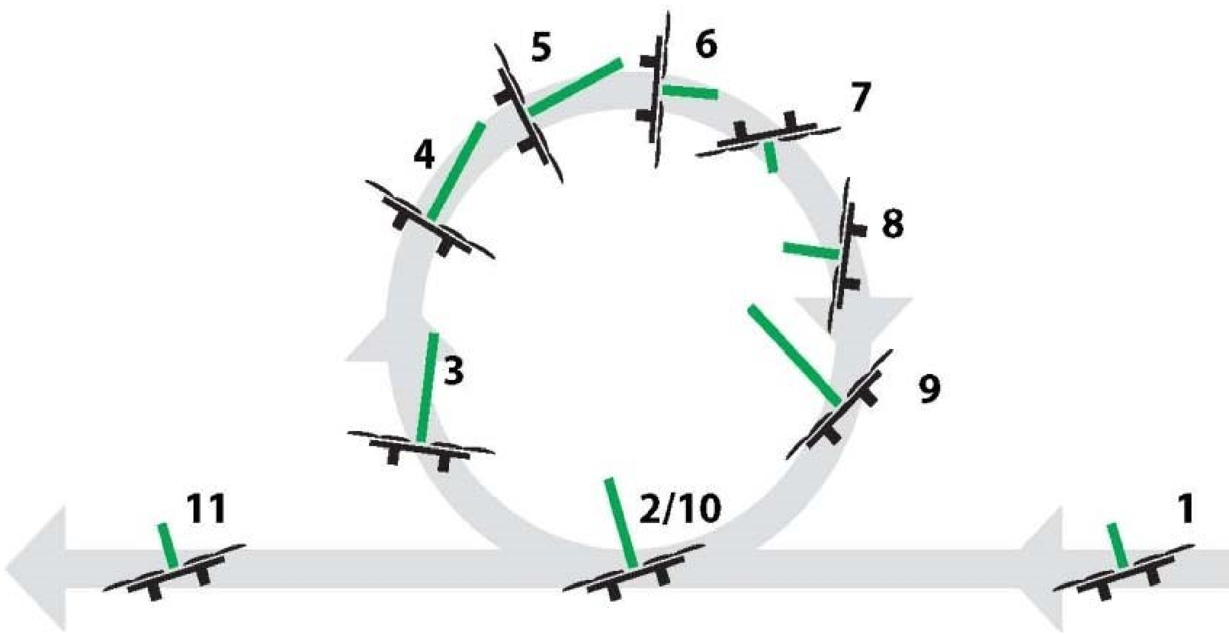
Candidates Name	**MFNZ Number**	**Date**	**Signature**
Examiner's Name	**MFNZ Number**	**Date**	**Signature**

	FLIGHT TASK	**COMMENTS**
(a)	Carry out pre-flight checks as required by the MFNZ Safety Codes	
(b)	Perform one hovering 'bow tie	
(c)	Perform one four-point pirouette	
(d)	Perform one 'Top Hat'	
(e)	Take off and climb to a safe altitude	
(f)	Fly a left rectangular hand circuit	
(g)	Fly a right rectangular hand circuit	
(h)	Perform one figure eight at circuit height	
(i)	Perform one twenty second nose-in hover	
(j)	Perform one loop	

(k)	Perform an approach at 45° to the vertical, landing within a predetermined two metre square	
(l)	Complete post-flight checks as required by the MFNZ Safety Codes	
Answer five questions from the list of mandatory questions on legal aspects of model aircraft flying.		
Answer satisfactorily a minimum of eight questions on safety matters based on the MFNZ Safety Codes for General Flying and Model Flying Displays and local flying rules.		

Appendix 5

Multi-rotor Loop for Fixed Pitch Multi-rotors



Technique

- Approach with a nice steady throttle to maintain a constant height, but flying forwards with enough speed to begin the loop.
- In the first quarter of the loop throttle is used to start the multi-rotor around a circular path, with only a small amount of elevator to maintain shape.
- In the second quarter of the loop, between 4 and 6 the multi-rotor will rotate to a little under 90°. During these stages throttle is used to essentially drive the multi-rotor over the top part of the loop.
- In the third quarter of the loop the multi-rotor is rotated a full 180° while using between 10-25% throttle. At no point, should the throttle be allowed to drop to zero or control can and will be lost.
- In the final quarter of the loop the focus is on using throttle to catch the multi-rotor while using elevator to finish the shape of the circle and fly out.
- Aim to continue to carry the same speed on exit.

NB: This is a rough guide that should be adapted to suit your own multi-rotor

Appendix 7

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 flybar-less 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. 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 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 of maintaining their altitude.

Multi-rotor Pre & Post Flight Checks

(A) Checks before daily flying session.

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

(B) Checks before and after each flight.

- If the multi-rotor suffers damage or a heavy landing, recheck all (A) above.
- Check all controls before starting especially for binding links or slowing servos.
- Check for vibration and eliminate before flight.
- Check that all wiring is secure and cannot become entangled with any moving or rotating part, especially the receiver aerial.
- Before starting insure all switches are in the correct position for take-off and the correct flight mode selected before **EVERY** flight.
- 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)
- 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 ensure 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 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. Thus, 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) typically requires compass recalibration

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 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. GPS 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, whereas 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 multirotor 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.