The Honourable Company of Air Pilots

TEACHING NAVIGATION

A GUIDE FOR INSTRUCTORS

Teaching Navigation – A Guide for Instructors

Foreword

This document has been produced to provide instructors with a guide for teaching navigation. As with all other general guides, it is impossible to dictate the exact structure that the training should follow. This document provides a general framework that encompasses what is believed to be best practice and forms a coherent series of airborne lessons. These lessons will fully meet the Part-FCL PPL(A) syllabus requirements for Navigation (Exercises 18 A, B & C), if followed.

As always, the variables of aircraft type, student ability, local airspace considerations and weather will ultimately dictate the teaching methods, the construction of each flight lesson and the exact order of events.

Initially, this document discusses and summarises the training which should have been completed prior to reaching the navigation phase before going on to discuss a series of six flight lessons including briefings. The early flight lessons deal with basic visual navigation techniques. It is essential that these techniques are understood and that competency is demonstrated before any solo navigation takes place. The later exercises cover Radio Navigation and the use of Global Positioning System (GPS). Additionally, this document suggests some advice regarding the structure of the solo navigation exercises and the qualifying cross country flight.

Introduction

Poor navigation is often cited as a potential factor in many accident and incident reports. Amongst these, Controlled Flight Into Terrain (CFIT), forced landings due to fuel starvation and airspace infringements are typically associated with inadequate flight planning and weak navigation technique. As a result of an unacceptable increase in the number of airspace infringements ("busts") the CAA commissioned the On Track study, the results from which were published in 2003. One of its findings was:

"Navigation training lacks any form of detailed instructional guidance or standardisation and relies instead on instructor interpretation of the limited training syllabus. Unfortunately, instructor training in navigation techniques is often poor, which results in a level of pilot instruction ranging from "read the book" to valuable, effective teaching".

One of the aims of this guide is to address some of the concerns of the On Track study, hopefully helping to reduce the incidence of airspace busts as well as having a beneficial effect on the number of instances of other navigation related incidents and accidents.

As mentioned in some other instructing guides, the integrated teaching of flying training is of utmost importance. It is inappropriate and ill advised to present any ab-initio course of training as a series of stand-alone lessons. Each lesson should link in with the next providing a range of interconnected skills and a sound knowledge base such that the skill test/assessment at the end of the course should almost be a formality. Certainly, the skill test should not ask anything new of the candidate if the course of training was properly conducted.

Where training has become disjointed, a typical student reaching the navigation phase of the training may have issues with some or all of the following problems:

a. Inability to understand chart symbology.
b. Inability to judge distance from a ground feature whilst in flight.
c. Difficulty with R/T communications – specifically changing frequency and opening a new service from a different ATC agency.
d. Understanding weather forecasts, charts and wind forecasts.
e. Inability to fly straight and level in trim!
f. Not understanding Human Factors, and the principles of Threat and Error Management, or how to apply the techniques to achieve a safer operation of the aircraft.

Each of these problems can be addressed through competent instruction at an earlier phase of the training. Some examples are given below.

The navigation phase should not be the first time that a student has worked with a chart. At the end of each of the previous lessons that were conducted away from the circuit, a rejoin will have been necessary. If from early on the student is in possession of a chart, then on rejoin a discussion can take place between instructor and student as to their present position with direct reference to the chart. Specifically, asking the student to show you on the chart where they think they are, discussing the symbology and getting the student to estimate the distance to a prominent feature from your present position will achieve this aim. Initially, the student's estimates will be somewhat wayward but with the experience built up through practice, this will build the experience and knowledge needed prior to the navigation training commencing.

The use of the radio should be phased in over the course of the lessons, with minimum exposure during the initial exercises building up to the student taking more and more responsibility as the course of training progresses. Certainly, by the end of the circuit phase the student should be dealing with all of the communications prior to leaving the circuit and after rejoining. Competency with the calls necessary for departing and rejoining the circuit should quickly follow thereafter. It is all too easy for the instructor to make the rejoin call to the ATC unit on completion of each lesson, especially when the frequency is busy and time is pressing to get back for the next lesson. In some circumstances this is the correct course of action, but whenever possible the student should be encouraged to make the R/T call(s).

During the exercises completed post circuit training (such as Advanced Turning and Forced Landings) it is the simple option for the instructor to elect to remain on the initial frequency for the duration of the lesson. However, students can gain much if they are taught and then practise how to obtain a service from another agency such as the local LARS or FIS provider as part of these lessons.

From early in the course an instructor should be teaching, on a drip feed basis, the skills and processes necessary to cover the actions prior to flight such as weather assessment, checking of NOTAMs, etc. If at an early stage time is taken to teach how to assess the suitability of the current weather from the available weather documentation (as well as looking out of the window!), thereafter it can become the student's task to check the weather before each lesson. Subsequently the time-pressed instructor will only need to ask a few pertinent questions to see if the student has made a realistic judgement of the conditions. It is important for navigation that a pilot can make reasonable assessments of cloud base and the wind vector at 2000'. If the ability to assess these weather factors can be learned early in the course and then practised, then this skill will be second nature by the time the navigation phase of training begins.

If the student is unable to climb on a heading to an altitude, level off and trim for straight and level flight, then successful navigation will prove to be near impossible. Quite simply, if the student reaches the navigation phase without mastering these basic skills then further teaching and practice of these fundamental skills will be required before the navigation training can begin.

Threat and Error Management (TEM) techniques should be discussed from the outset of the training course, with the application of the techniques demonstrated and practised at every stage. Human Factors should be considered with each exercise and the relevant items discussed. If these “soft” skills are ignored, the student may find difficulty with identifying potential risks and hence with the decision-making process - essential during the planning and execution of any flight, but particularly applicable to cross country navigation. More information discussing TEM techniques issued by the Australian CASA is available at the following web-link:
http://www.casa.gov.au/wcmswr/_assets/main/download/caaps/ops/5_59_1.pdf

In summary, the student will be placed at a serious disadvantage if the instructor fails to take the initiative and leaves the teaching of all of these items until the navigation lessons. The learning curve during navigation training is often steep; without an integrated approach, the navigation training might just be too much for some students to cope with.

Initial VFR navigation

Navigation for the ab-initio pilot centres on visual map reading exercises. Before any airborne navigation exercise is undertaken, the student requires considerable study in the theory of navigation and active instruction in pre-flight planning techniques including TEM and human factors.

As a general rule of thumb, approximately the same amount of time needs to be allocated to ground instruction prior to a navigation airborne exercise as for the airborne exercise itself.

Navigation is best accomplished when working to a routine or work cycle. This can be established during flight planning by spacing position fixing at regular intervals along the route about 6 to 9 minutes apart, and planning other essential activities at suitable points between. The objective is to allow the pilot time to fly accurately straight and level (lookout, attitude, instruments!) between each event according to the flight plan. This is a most important aspect of successful navigation and should form a significant part of the airborne teaching. Time is of the essence in visual navigation!

The following suggested lesson plans encourage the student into the routine of navigation. They also teach the student progressively how to manage the actions at the fix (or waypoints) without the workload causing stress to the detriment of their flying ability.

Lesson 1 (Exercise 18A)

The primary aims of this exercise are:
To teach how to conduct pre-flight planning of a navigation route, including Threat and Error Management.
To teach how to conduct airborne navigation technique / work-cycles to achieve visual navigation.

Prior to the first airborne navigation exercise, a briefing should be given during which the flight planning for a simple triangular route should be taught and practised. The total flight time for this route should take approximately one hour, each leg covering between approximately 15 to 20 minutes of flight time at normal cruising speed.

The chart should be prepared with the appropriate lines to depict the route with necessary marks to assist with the monitoring of the navigation once airborne. Generally speaking the less clutter that there is on the chart the better. Most students have a tendency to put too much on the chart and block out useful features. Suitable fix points should ideally be identified and studied at an early stage. The Royal Institute of Navigation's guide "VFR Route Planning for GA Pilots" gives more detailed advice and is available through their web-site.

There is a tendency for most GA pilots to select whole thousands of feet for their chosen cruise altitude (2000', 3000', etc). Particularly in busy airspace which underlies controlled airspace, this tendency may increase the risk of collision by reducing the number of cruising levels used. Consideration should be given to discussing with the student the use of some intermediate levels (1700', 2200', 2700', etc) potentially to reduce this risk.

In addition to the standard preparation for flight actions (NOTAMs, etc), an assessment should be made of expected maximum drift from the forecast wind, and what rough headings and groundspeeds the student should expect on each leg. More accurate calculations should then be completed using a 'Dalton" type flight computer (whizz-wheel), an electronic calculator/flight computer, or MDR (Mental Dead Reckoning) techniques. Compare the final calculations with the rough estimates, and flight planning software if available, before completing the Plog.

To plan with the degree of accuracy required by the PPL (A) Navigation Theory examination paper requires the use of a flight computer of some sort. However, for practical navigation the results obtained using MDR are perfectly adequate, and instruction in MDR techniques as the primary means of flight planning is highly recommended. If the student normally uses MDR for his flight planning on the ground, then when the in-flight diversion needs to be calculated he will be perfectly comfortable with this technique.

(More detail on MDR is contained at Annex A, and an example of a chart annotated ready for navigation is given at Annex B)

The final stage of the planning process is to review the route, identifying, or ideally refreshing, from the chart what might be seen at each of the fixes and turning points so that there is an awareness of what to expect prior to getting airborne. This is the time to identify potential threats (e.g. lowering cloud, increasing wind, choke points, circuit or instrument traffic at aerodromes) and human errors (e.g. misreading headings or times, distraction by ATC) and discuss their management (e.g. early correct radio calls, gross error checks). If a satellite navigation device is available, the route should be loaded into it, for future use as a back-up.

By this stage of the training course all students should be able to carry out a pre-flight inspection of the aircraft and a solo engine start. Likewise, taxi-ing, checks prior to take-off and the take-off itself should all be practised by the student. If appropriate a short field or soft field take-off technique might be taught or practised.

Prior to take off, having completed all checks, the initial stage of the flight should be reviewed, including circuit departure, visual references, speeds, altitudes etc. After take-off and initial climb the instructor should take control and teach how to correctly identify the start point, reading from map to ground, and carry out the pre-WHAT checks – checking the **W**eather ahead, then **H**eading, **A**ltitude and **T**ime from the plog. The instructor should position the aircraft over the start point at the planned altitude, speed and heading, noting down the time and starting the stopwatch. Having established the aircraft straight and level, in trim, and on track, teach the gross error check – orientate the map to track and compare features on the ground with the track drawn on the chart. Teach the repetition at this stage of the WHAT check to confirm that the planned values on the plog are being flown, and confirm the next fix and the time to look for it. Stow the map and hand over control to the student to fly straight and level. This is an important step as it demonstrates to the student that the map is not required all the time that we are navigating; we are not required to follow our progress with a finger on the chart! Ask the student to complete the en-route checks (usually FREDA or similar).

Not less than 2 minutes before the next waypoint/fix, take control back and teach how to fix the position of the aircraft. Use big features initially, and demonstrate the working cycle from watch/stopwatch, to map, to ground. Having fixed the position, note this on the chart and teach how to correct for any error both to track and ETA.

There are three suggested techniques for correcting any off-track error:

1. Fly visually to the fix or position on track and then resume navigation on a heading revised to remove track error (only use when the fix is within about 30 degrees of straight ahead).
2. Double track error correction to heading to correct to track in equal time. (This can be a correction direct to turning point in equal time if the fix happens to be at the ½ way point and there is no other reason to resume planned track earlier).
3. Use a "standard closing angle" to regain track, then resume navigation on a revised heading.

In some parts of the UK the airspace structure is such that returning to track promptly is essential to prevent an airspace bust, hence the emphasis on teaching track correction techniques that will achieve this aim. For additional detail on these three methods of track error correction refer to the guidance given by The Royal Institute of Navigation in their "Visual Navigation Techniques for Pilots" guide produced in association with the Air Pilots. This is free to download from their web site www.rin.org.uk via "Groups and Branches/ General Aviation Navigation Group".

Teach each method for correcting track on an opportunity basis. Adjust the heading appropriately and once again hand over control to the student to maintain straight and level flight. If available, a satellite navigation device should confirm the aircraft's position once it has been identified from the chart.

With approximately 2 minutes to run to the turning point, take control and teach the actions to identify the waypoint and execute the turn onto the next leg including WHAT checks and gross error check. Make it clear to the student that this is effectively the same routine as was completed at the start point. Developing these work cycles are an essential part of the navigation training.

Essentially, during the first leg, navigation tasks are completed by the instructor who also does the lion's share of the flying, with the student only handling the controls during the straight and level portions of the cruise. A common instructor error is to leave the student in control whilst teaching the navigation elements. It is important that the student can give his full attention to the instruction being given.

During the second leg the same work cycles are used, with time being the prompt to instigate the next work cycle/actions. The emphasis now changes with the student given practice in completing the navigation tasks (position fixing and calculating corrections to heading and ETA) whilst the instructor flies the aircraft. Again the exception is the portions of the leg when the map is stowed, during which the student should be in control.

For the final leg, the student will have been taught all the necessary work cycles to complete the leg from both a navigation and flying perspective, so should be tasked both to fly and navigate. However, they may well still require some assistance, particularly with any corrections at the fix. Do not end up "flying the leg by proxy" with endless prompts. Try to give them the opportunity to practise, only intervening if it seems the purpose of the leg will be lost.

Having navigated (hopefully successfully) on the third leg, the aeroplane should be close enough to the aerodrome to allow the student to organise the rejoin, and fly the circuit and landing. To prove the accuracy of the student's estimate for the field, it may be useful, if locally permitted, to join in the overhead. Arriving in the overhead places the aircraft in a suitable position to practise a forced landing pattern if desired. During navigation training flights it is all too easy to allow the student to complete a series of normal approaches. It is recommended that currency be maintained in all the landing techniques by tasking the student to complete flapless and glide approaches as part of the training on each lesson.

Lesson 2 (Exercise 18A)

The primary aims of the second navigation exercise are:

To revise basic flight planning and visual navigation, including Threat and Error Management.
To teach how to divert off track to avoid weather and return to track once clear.
To teach the en-route diversion technique from a known position to a suitable alternate destination.

A thorough briefing will be required before this flight lesson is conducted, particularly the techniques to be used for the diversions and the threats or errors which could require one. Hopefully, the student will be able to plan the route and carry out all the pre-flight actions, including threat assessment**.** For convenience, the student should plan a three-leg route to a remote destination, each 15 - 20 minutes flight time (an en-route diversion back to the airfield will be flown from a fix on the third leg, ideally the first one).

The student should carry out the start, taxi and take-off. They can then climb to the start point and set course on the first leg. The student should be capable of navigating to the first turning point with the minimum of instructor input using the techniques taught in the previous lesson.

Approaching the turning point, again the student should be able to identify the turning point and set course along the next leg. Once the aircraft is successfully established on track, take control and teach the correct technique to leave track to avoid weather/obstacle, parallel track if appropriate, then to rejoin track – a dog-leg diversion. If possible try to rejoin track before the fix so that the success of the dogleg technique is confirmed. After the fix, allow the student to practise this dogleg diversion, rejoining track before the turning point. If available, a Satnav device can confirm that track has been regained.

On reaching the second turning point, take control and teach how to plan and perform a diversion to an alternative destination – in this case the airfield. Start by nominating a suitable start point, probably the first planned fix. Draw a line on the chart from this point to destination, marking on suitable fix(es). Measure both the track and distance (use of a simple plotter is acceptable but a good estimate by eye/thumb will still be effective) and calculate heading, groundspeed and time using MDR techniques. Once the planning is complete, hand control back to the student, as from this point onwards the techniques to start and then navigate this leg are no different to any other leg previously flown. Emphasise that the aircraft can be turned onto the planned heading before calculating groundspeed and time. If a Satnav device is available, ensure the student can select a diversion aerodrome on it.

Once again, be constructive on the use of the rejoin and circuit.

Lesson 3 (Exercise 18A)

The primary aims of this exercise are:

To revise all previously taught techniques, including Threat and Error Management.

To "landaway" at another airfield.

To cross a MATZ or negotiate controlled airspace.

To teach the procedure to be carried out if lost.

A briefing will be required covering the topics listed in the aims. If desired, ask the student to plan a single leg to and from the land away airfield, with multiple fixes en-route if required due to the distance being covered. Ideally, select an airfield within 30 minutes flight time and one which might be selected by the student should he need to divert during a later solo navigation exercise. Alternatively, select an airfield that is to be used as a destination during the qualifying cross-country exercise. If a MATZ crossing or controlled airspace entry can be included on this leg, this would be ideal to give the student experience of dealing with these. Discuss the R/T formats required. The student should be able to carry out all the normal planning without much assistance. Ensure that the landing and take-off performance at the landaway airfield is considered using the aeroplane Flight Manual / Pilot's Operating Handbook.

The student should depart and set course in the normal fashion. Throughout the flight the student's task is to fly the aircraft and navigate using the previously taught techniques. Approaching the MATZ/controlled airspace, the instructor should take responsibility for the R/T in order to demonstrate the correct initial R/T call, then the request for, writing down, and read-back of the clearance. After leaving the MATZ/controlled airspace the student can resume responsibility for the R/T. Some guidance may be required to enable the student to orientate himself as the destination airfield is approached. It is probably better to take control and demonstrate a join at the airfield if it appears to be becoming difficult for the student, rather than make a hurried join with the instructor delivering instructions for the student to follow. Once established in the circuit, control can be passed back to the student to complete the circuit and land. On the ground, the procedures for refuelling and booking in/out can be taught.

After departure from the airfield and once settled on track for the return flight, an in-flight diversion can be practised. Successful completion of this revision places the aircraft in a position from which the lost procedure can be taught.

It is important at this point to differentiate between being lost and being "temporarily uncertain of your position". The latter state is quite normal during visual navigation. When flying accurately straight and level with the map stowed, it is appropriate that when over unfamiliar territory we are unable to say exactly where we are at a given time. This differs from a lost condition, which exists when the time we expect to be at a fix passes with no sign of the fix, and with little on the ground relating to the features we would expect to see on the chart at this point.

The instructor needs to emphasise the priorities if the student becomes lost. Safety of the aeroplane is of prime importance. Remaining in VMC, maintaining an effective lookout and carrying out a FREDA check (particularly DI to compass cross check and fuel endurance remaining) should be the first actions. Next, assuming a Satnav device is unavailable, note the time, then speak to ATC, ideally declaring being lost to the agency currently being worked. If this is not possible then a PAN call to D&D on 121.5 MHz should be made. Make the point that very often this step alone will resolve the issue. If the aircraft is transponder equipped, a change of transponder code from ATC will highlight the aircraft on radar, or perhaps the auto-triangulation function will enable them to locate it. The option of doing a “training fix” with D&D to illustrate this to the student is often a worthy demonstration and should be included at some point during the training.

Next, teach the actions to be taken should the radio be unavailable or the assistance from ATC ineffective. Point out that the aircraft may not be within radar coverage or at a high enough altitude to allow auto-triangulation.

In this case teach to read from ground to map. Identify any distinctive ground feature to fix position positively (a line feature leading back to track or a prominent fix point). Re-calculate the route. If no fix or line feature is available, then check actual heading flown, DI alignment and time. From the last confirmed fix, plot the track actually flown for the appropriate time to make a DR fix. Plot this fix on the map and construct a “circle of uncertainty”, radius 10% of the distance flown since the last reliable fix. Select a line feature on the map outside the circle of uncertainty, and set heading towards it, map reading from ground to map. On reaching the line feature, fly along it until the position is established.

The result of this teaching should give a fix on the chart, from which the student can practise calculating an in-flight diversion to return the aircraft to the airfield.

Lesson 4 - (Exercise 18B – Low Level Navigation)

The primary aims of this exercise are:

To teach the actions prior to descending.
To teach the differences when map reading at low level.
To teach the effects of wind and turbulence.
To teach the join and circuit at low-level (simulated bad weather circuit).

This lesson is best taught when there is sufficient surface wind strength to give obvious drift. However, if the surface wind is so strong it generates significant turbulence then the teaching points of the exercise are likely to be lost as it will quickly become merely an exercise in control of both aircraft and stomach.

A thorough brief will be required prior to flying this exercise. Discuss the effect of operating at a low-level on the ability to see features on the chart, particularly the inability to see lateral features (towns, lakes, wooded areas, etc) until very close, whereas vertical features such as masts, aerials and some elements of terrain become more obvious. If operation at low-level is anticipated then these factors should be considered at the planning stage. Discuss the checks recommended before descent and the configuration to be used, and revise Rule 5 from the Rules of the Air Regulations (sometimes referred to as the 1000' and 500' rules). Brief the possible hazard of low flying military traffic, and the very short time available for coping with emergencies.

The visual effects created by the wind at low-level should be briefed, including the false sense of speed with significant head/tail wind components and the tendency to interpret drift wrongly in the turn as an out of balance condition. The effects of turbulence should also be considered. The bad weather circuit and landing can be briefed as a further variation of the precautionary forced landing procedure covered during Exercise 17. As with the previous exercises, the student should be able to plan a simple route and carry out all the pre-flight actions.

The student can carry out all the necessary actions and procedures to get airborne and set off on track at normal operating altitude on the first leg of the planned route. Once established, the instructor should take control. Teach the checks needed prior to descending to low-level (approximately 500' AGL). Normally an en-route check (such as FREDA) will suffice, including selecting mixture to RICH and the booster pump ON if appropriate. Additionally, if in receipt of a service from a radar ATC unit, it will be prudent to advise them of the intention to operate in a different altitude band; at low-level they may be unable to see a consistent return on the radar. If the need to operate at low level is due to poor weather then revise the adoption of the slow, safe cruise configuration. If this configuration is used, a correction to the estimated time for the leg must be calculated.

Once established at the lower cruise altitude, teach the changes in features that are now visible, as well as the need to anticipate ground features coming into view and the need to anticipate rising ground. Teach how to assess a safe height visually. Demonstrate the value of being able to follow a suitable line feature to achieve the next turning point, if one is available. When following a line feature, revise the need to keep the feature on the left, and maintain an awareness of the heading being flown and time. At the next turning point, climb the aircraft back up to the normal operating altitude. Hand control back to the student to fly the second planned leg, initially at the normal planned altitude. Once established on track, simulate a lowering cloud base ahead by nominating a maximum operating altitude and allow the student to practise descending to and completing the leg at a low level.

On completion of the leg, take control and demonstrate the wind effects by flying a racetrack pattern discussing on each leg the precise effect the wind is having. Also, teach the need to increase power, if required, to maintain the indicated airspeed during the turns. Allow the student to practise the turns whilst maintaining airspeed and balance.

On completion of this part of the exercise, the student can then practise planning a diversion leg to return to the field, at low-level if possible. Take control as the field is approached, to teach the bad weather join and circuit to land.

Lesson 5 (Exercise 18C – Radio Navigation – VOR/NDB&ADF/DME)

In common with the previous lessons, the success or otherwise of the airborne part of this exercise is often determined by the quality of the ground briefing given before the lesson. If, once airborne, the student demonstrates a weak understanding of the correct interpretation of the cockpit indications, the teaching will become protracted and possibly only lead to further confusion.

The exact format for teaching this exercise will depend upon various factors including the equipment fit of the aircraft to be used, the location and availability of the beacons and their relative position to the airfield. To meet the syllabus requirements the following elements must be included:

How to select, identify and display the radio beacons correctly.

Obtaining a position fix using two VORs.

Intercepting and maintaining a VOR radial both "TO" and "FROM" the VOR including the indications on passage over the VOR.

Orientation relative to the NDB

Homing to the NDB.

Modes of DME operation – distance, groundspeed and time to run.

During the teaching of these items it should be emphasised that the aircraft is still being operated in visual conditions under VFR so lookout must not be compromised. Note that there is no requirement in the PPL(A) syllabus to be able to carry out radio navigation whilst instrument flying.

Another important point of technique which needs to be emphasised is the need to fly selected headings to achieve the desired needle indications. Do not allow the student to chase the needles endlessly!

Lesson 6 (Exercise 18C – Radio Navigation – GNSS)

A syllabus of training for the use of GNSS as an aid to VFR navigation has been formulated by The Royal Institute of Navigation and is available on their web site.

As with the previous lesson the exact nature of the lesson content is determined by the availability of GNSS to the student – a panel mounted Satnav is not a standard feature in most training aeroplanes. The training will by necessity have to be based on the particular make/model of GNSS receiver with reference to the manufacturers user guide. Hand-held devices are as useful as dedicated aviation GNSS units, and in some cases are easier to operate.

As a minimum the following points should be covered during the initial navigation training:

1. How to initialise the unit – database validity and satellite signal integrity.
2. What to do if operating with an expired database
3. How to load, check, and activate a planned route, either manually or through another electronic device before flight.
4. How to use the "direct to" and/or "nearest" function for diversion.
5. How to identify controlled and restricted airspace on a map display.

During previous exercises, the student should ideally have learnt how to integrate the use of GNSS into the normal visual navigation technique. If not, this exercise is the opportunity. Even if the route has not been loaded, a moving map can indicate gross errors.

Other uses of a Satnav should be introduced and practised if possible:

a. Changing the range and detail shown on a moving map.
b. Using GNSS track and groundspeed indications to detect errors in the DI and compass.
c. Obtaining frequencies and aerodrome charts from a valid database.

As the number of VORs and NDBs reduces, reliance on GNSS as an aid to navigation is increasing. It is important that the instructor fraternity embrace the technology and include it as an essential part of the training syllabus.

Solo Navigation Practice.

The current Part-FCL PPL(A) syllabus calls for 5 hours of solo navigation practice, which includes the "Qualifying Cross Country" (a route of at least 150nm with two stops at airfields other than the airfield of departure). Practically, this will mean at least two solo navigation flights of approximately 1 hour 15 minutes duration, in addition to the Qualifying Cross Country.

The scheduling of solo practice will be driven by the normal constraints of student ability and weather. Prior to the first solo cross-country flight, it is recommended that the following items have been achieved:

Competency in the skills taught in Lessons 1-3 of this framework document including use of R/T.
A pass in the theory examinations in Air Law, Flight Performance and Planning, Navigation and Meteorology.

It is also recommended that all the Navigation dual training exercises are completed before the student attempts the Qualifying Cross Country flight. Prior to any solo navigation flight, it is considered best practice that the supervising instructor completes a briefing certificate in duplicate, although after the first solo the student should be expected to brief the instructor. One copy should be retained on the ground in the student's record of training, the student should take the other copy with them on the flight (an example is given at Annex C). This will satisfy the requirements of *Part FCL.045*. One of the other requirements contained within *Part FCL.045* are that the student must also carry photographic ID. In any case, the pre-flight briefing should be at least as thorough as the ones for the previous dual flights, as should the post-flight de-brief.

All solo routes should be carefully chosen (and if chosen by the student carefully monitored) to minimise problems such as airspace or high ground, unless these problems are intended to give the student specific practice. Routes should include obvious features to be used as fix points and gross error checks. The first solo route should have been flown previously dual.

The Qualifying Cross-Country Flight

For the Qualifying Cross Country flight, a certificate should be carried by the student to be signed at each airfield visited.

The choice of aerodromes to be used, which do not have to lie at the corners of the 150 miles route, is likely to depend not only on airspace and weather considerations, but also on student experience and ability. There may be no need for the student to have landed at both these aerodromes dual, but the first solo landing away from base should not be at an unknown aerodrome, and any aerodrome at which he has not previously landed dual should not present problems such as short runways, unfamiliar air traffic services or crosswinds.

Common Student Errors

Most faults stem from over concentration on map reading, to the detriment of flying accuracy and airmanship. This is usually because the student is frightened of becoming lost if he does not continually monitor his position. Insist on the correct application of the event technique, and instil an understanding that the techniques will always work if correctly applied. The student needs the confidence to believe that the techniques will work to be able to put down the map (and Satnav) and fly accurately.

Students often misidentify fixes and turning points. This is usually a combination of inadequate fix study and faulty map reading techniques. They tend to look only for small ambiguous features, and often ‘identify’ the wrong one. They should be taught to look at the overall picture, and to use large unambiguous features to identify smaller pinpoints. They should confirm with a Satnav device if available.

Students often make errors in MDR calculations and apply corrections in the wrong sense. A “common-sense” check to any calculations prior to applying any correction can often negate these errors.

Common Instructor Errors

Instructors may fall into the trap of using local knowledge to orientate themselves or even when navigating. The student learns nothing from this. Make sure you refer only to features marked on the map.

During the initial navigation lessons instructors sometimes take control too late. This results in them giving themselves insufficient time to make their points and to involve the student actively in map reading. The instructor should do as much planning as the student, although with experience taking much less time.

Instructors often do not allow the student time to recognise his own mistakes. The student will usually learn far more from correcting errors than from a flight which goes exactly according to plan.

Especially during the radio aids lessons, instructors can allow their lookout to deteriorate and concentrate on instruments at the same time as the student. A Traffic Service may assist.

Careful student solo supervision is vital. Even the most competent student can and will make major errors in their planning. The most important part of a solo briefing should be considering Threat and Error Management.

Annex A – MDR Techniques

The standard MDR techniques are included here for reference.

Maximum Drift.

The maximum drift will be experienced when the wind is at right angles to the track. In this case the drift can be calculated as follows:

Max Drift = Wind speed x 60/Groundspeed

At 90 Kts GS, with a wind speed of 15 kts Max Drift = wind speed x 60/GS

= 15 x 60/90

= 15 x 2/3

= 10 degrees

For practical purposes we can usually use TAS instead of groundspeed.

Expected Drift

The expected drift can be calculated by first calculating the maximum drift (as above). To determine the proportion of this that the aircraft will experience first calculate the angle between the wind and track (wind angle). The proportions of maximum drift to be applied are as follows:

Wind Angle = 15° ; Drift = ¼ of Max Drift

Wind Angle = 20° : Drift = 1/3 of Max Drift

Wind Angle = 30° : Drift = ½ of Max Drift

Wind Angle = 40° : Drift = 2/3 of Max Drift

Wind Angle = 45° : Drift = ¾ of Max Drift

Wind angle 60° or more: Drift = Max Drift

An easy way of remembering these proportions is by the clock analogy – 15 minutes is ¼ of an hour; a wind angle of 15 degrees equates to ¼ of the max drift, etc.

Calculating Groundspeed

To calculate the head or tail wind component, subtract the wind angle from 90 and use the clock analogy as above to calculate the proportion of the wind.

If the wind speed is 30 knots and the wind angle is 60 degrees: 90-60 = 30.

30° equates to ½, so the head/tail wind component is ½ the wind speed = 15 kts.

Standard Closing Angle

Individual instructors may wish to calculate their own ‘standard closing angles’, preferably 30 degrees or less to minimise time delays. It may be worth considering that, if flying at a groundspeed of 120 knots, applying and maintaining a heading change of 30º for one minute will move the aircraft one nautical mile in that direction. If flying at 60 knots, it takes 2 minutes at 30º to move that one mile, and at 80 knots it takes 1½ minutes per mile.

Annex B – Example of Chart Prepared for Flight

Route – Goodwood to Greenham Common

Annex C

Example Solo Navigation Briefing Certificate

NOTES

1. One copy of the Solo Navigation Briefing Certificate is to be left at the base aerodrome, when completed, and the other carried by the student.

2. The student should carry a PPL Qualifying Cross Country Certificate on the final qualifying cross country flight (or any land-away) and return it duly completed to the authorising instructor.

I certify that the student pilot has been briefed for a solo navigation exercise as follows:

From…… To…… .

..... To ……..

..... To…… .

for an ETD of. . . . . hrs UTC/local on (date) ……. .

The navigation flight plan has been checked and the following items discussed and, where applicable, the required facts noted on the flight plan.

ITEM

1. WEATHER
Altitude to fly and terrain clearance (Lowest Altitude to Continue).
Destination(s) actual.

2. ROUTE
Need and method for maintaining VFR flight.
Military zones, and procedures for crossing (if applicable).
Danger areas (if applicable).
Altimeter setting regions.
Applicable NOTAMS, regulated airspace & entry /exit lane procedures.
Current navigation warnings including royal flights.

3. DESTINATION
PPR (if applicable), joining procedure/position reports/knowledge of landing runways.
Land away procedure (including refuelling instructions and booking in/out).

4. ABNORMAL AND EMERGENCY PROCEDURES

Knowledge of controlled/regulated airspace and related minimum altitudes/levels.
Action in event of intrusion into controlled airspace.
Action in event of weather deterioration and/or fuel shortage.
Action on becoming lost.
Use of R/T including position reports - use of D/F - RTF PAN procedure.
Action in event of an unscheduled landing.

5. AEROPLANE

Sufficient fuel and oil including reserves.
Aeroplane serviceability.
Mass and balance.
Performance.

6. RADIO

Use of radio (when applicable) if lost.
RTF MAYDAY procedure.
Selection and noting of COM and NAV frequencies for normal and emergency operation.

Instructor's signature. ……..

Licence number ……...

I certify that I have been briefed for the navigation exercise detailed above and understand that in the event of an unscheduled landing I will contact the CFI or his/her deputy by the quickest possible means and act according to their instructions.

Student pilot's signature …….

Date……... Time……. (UTC/local).