Safety Regulation Group

Civil Aviation Authority

Civil Air Displays

a guide for pilots

contents

introduction

Air displays are now one of the most popular spectator events in the United Kingdom. On average there are over 250 civil flying displays each year attracting in excess of two million spectators. It is of the utmost importance in the interests of public and personal safety, that those who participate in such displays operate to the highest standards. These notes are intended to provide advice to display pilots to help them avoid the pitfalls which have been experienced in the past.

the law

The rules governing the conduct of civil air displays in the United Kingdom are given in the current Air Navigation Order, The Rules of the Air Regulations and comprehensively explained in CAP 403 – "Flying Displays and Special Events: A Guide to Safety and Administrative Arrangements".

guidance for display pilots

Display flying, especially aerobatics, is a specialised form of flying that frequently involves flying the aircraft close to the edges of the permitted flight envelope. Regrettably, most years, a small number of pilots are killed whilst displaying. Many of these pilots were highly experienced and extremely competent in their particular aircraft and display. What can be done to minimise the risk?

managing the risk

personnel fitness

There are a large number of factors which affect the outcome of a particular flight. Many of them are encountered well before the pilot gets anywhere near the aircraft. To be a successful display pilot you need to be well motivated, have plenty of free time, be relatively free of personal worries and enjoy a reasonable degree of personal fitness.

Any individual intending to enter the air display scene must have an insatiable desire to fly and be prepared to devote the majority of his leisure time to flying. As well as the actual display itself you will have to find time to rehearse, to transit to the various display venues and have the patience to cope with the inevitable weather delays. It is not sufficient to be simply physically fit, you have to be mentally fit and relaxed as well. It is no good thinking about the bank manager's recent nasty letter or your partner's parting shot when you are in the middle of your display sequence.

To summarise, make sure that you and your nearest and dearest are happy that you devote nearly all your free time to your hobby, and for you to be absent most weekends during the summer.

professional fitness

Having satisfied yourself that you are physically fit enough to become a display pilot you need to assess your professional fitness. You will need to review your overall experience in the light of the type of aircraft you are

going to display. You will need a current pilot's licence with an up to date Medical, Certificate of Experience or Test and, if required, an Exemption appropriate to the aircraft you intend to fly. Before performing a display in public, you must also hold a Display Authorisation.

As far as experience is concerned, it is difficult to specify precisely appropriate total flying experience when assessing professional competence. Much depends on the nature of the display. Whatever your experience, it is imperative to keep the complexity of your display programme in line with your experience. CAP 403 gives comprehensive coverage of those areas on which a Display Authorisation Evaluator will quiz you when you present yourself for assessment. Make sure you know your own and your aircraft's capabilities and limitations, particularly those unique characteristics your aircraft possesses which could catch you out at a crucial moment when flying close to the flight envelope boundaries during your display.

planning your display

Your sequence of manoeuvres should be constructed with a focus on the objective of your display, i.e. to entertain the public. Your workload to achieve this should always be well below 100% of your capacity in the aircraft you are flying and whatever the prevailing conditions (weather plus how much sleep, food etc you have had). You should always plan to have spare capacity to deal with the unexpected.

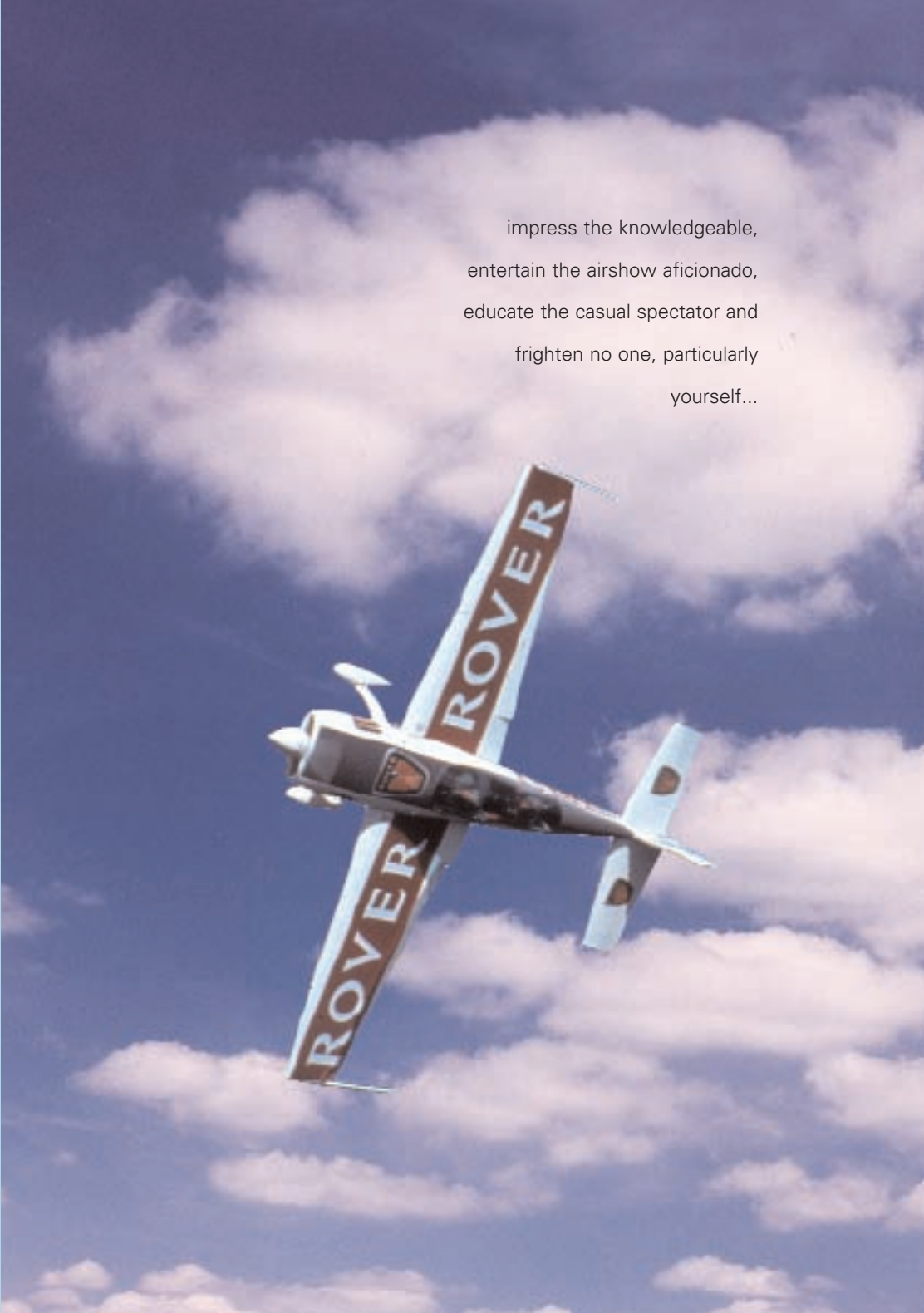
It is important that you have constructive and critical comment during your display planning and workup from an experienced display pilot who is preferably a Display Authorisation Evaluator experienced on your type of aircraft. Choose someone with whom you have a good rapport, mutual trust and respect. Then heed the advice given.

developing your display routine

You should remember the following:

- The most important single factor is safety
- The spectators should be able to see the whole of your display
- Select manoeuvres that:

impress the knowledgeable,
entertain the airshow aficionado,
educate the casual spectator and
frighten no one, particularly
yourself...



- Are well within your own and your aircraft's capability
- Can be safely flown at low level
- Show your aircraft to its best advantage
- Minimise flying straight and level between manoeuvres
- Reduce the risk of crashing towards the crowd e.g. with a barrel roll started parallel to the crowd the direction of roll should be towards the crowd leaving the aircraft going away from the crowd in the second – more dangerous – part of the manoeuvre.

- 'Display the aeroplane, not yourself.'

Developing a display sequence depends, to a great extent, on the type of aircraft being flown, what type of manoeuvres the aircraft is cleared for and the aircraft's power to weight ratio.

For example, a high performance jet fighter, such as the Hunter, has little difficulty sustaining, or regaining, speed and/or altitude during a low level display. The same cannot be said of a Chipmunk, and a different approach needs to be taken when planning a display for such different types.

The overriding factor in a display in a low powered aircraft is energy management. There is little point in starting a display in a Chipmunk with a loop at base height. Firstly, you will probably come below base height on the recovery (A BAD THING) and, secondly, if you make base height you will have little energy left for any subsequent manoeuvres. Low powered aircraft need to start the display high and trade height for speed as the manoeuvres are completed. Clearly, the high energy manoeuvres need to come early in the sequence while there is height and performance in hand.

The problem with high speed aircraft is ensuring that your display does not need a crowd line three counties long. You need to know how much airspace your aircraft takes up when performing the various manoeuvres. Take a piece of paper and draw a line on it representing a display line. Now, a slow roll takes about 10 seconds to perform and this equates to approximately 1500 metres at 250 kts and 2000 metres at 360 kts. Next you need to calculate the best radius of turn you can make at low level. The correct formula for this calculation is:

Radius (m) = speed (m/sec) squared and then divided by load factor (g)

To determine the radius all you need to do is execute a few steep turns at 1000 ft and note what 'g' you can sustain for a full 360º at the various speeds you intend to use during the display and then substitute these values into the formula.

You can now draw turns at each end of your slow roll line. See figure 1.

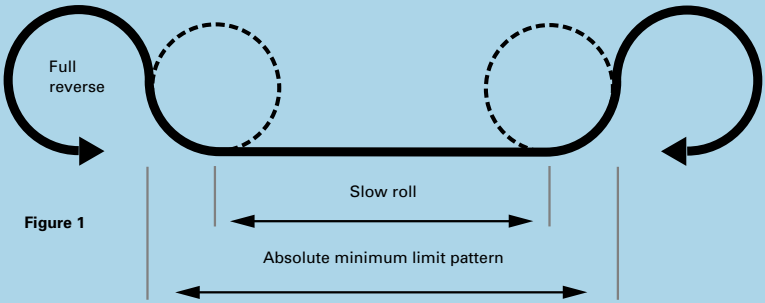


Figure 1

If you feel the above calculation is too complicated, a well known display pilot developed the following:

Turn radius (ft) = IAS (kts) squared and divided by 10 x G pulled

The advantages of the simpler formula are that it uses units that mean something to pilots, it can easily be completed and gives an answer that is 13% pessimistic. Thus, it will give you something in hand to deal with an on-crowd wind, inaccurate flying or the need to get perfect ground position.

You should now draw out your proposed sequence of manoeuvres on acetate sheets using a separate sheet for each manoeuvre, and use them to develop your display. A note of caution, make sure that the turns are not smaller than those calculated.

You will need to keep your sequence simple and have practiced such that you can perform your routine without making any major errors in positioning, entry speed and height.

to 99.9% of
those attending the show an
inside loop flown at 300 feet base
height is more impressive than an
outside loop flown at 600 feet base height yet which puts
more strain on pilot and aeroplane and which is more likely to become
screwed up...

in the experience of many long-time display pilots far more adrenaline is expended on the transit flights to and from the display venue than is used up on the display itself - do not become yet another statistic - far better to be down here wishing you were up there than the reverse.

In constructing a display sequence – you will need to take account of the following:

- Appropriate distribution of vertical and horizontal manoeuvres throughout the sequence

- Energy management

- Appropriate use of noise throughout the display

- The appropriate use of A, B and intermediate display axes. See figure 2. Remember that misjudged on-crowd B Axis pull ups are the most common cause of minimum separation distance infringements.

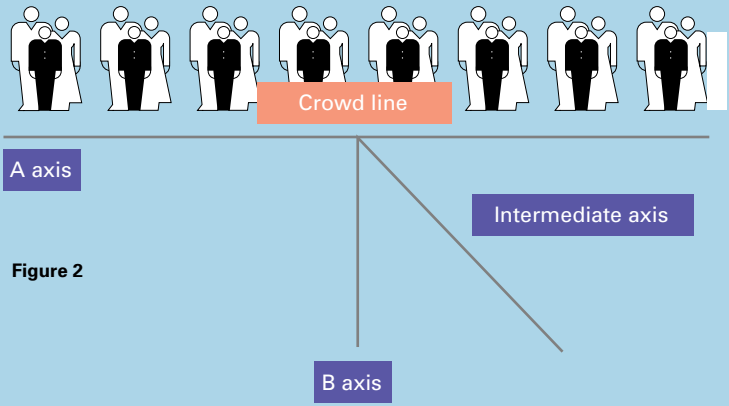


Figure 2

When you are in your first display season try to avoid having to initiate a display sequence straight after take-off. It is best to clear the display area and settle down before entering the display. If you are flying an aerobatic sequence, use the time to do an inverted flight check for loose articles and correct fuel flow and oil pressure.

You will need to be aware of the effect on your display of the wind strength and direction, relative to the crowd line, and adjust your manoeuvres accordingly.

Whatever you initially calculate you will probably find that your sequence in the early days takes longer than expected; however, this will correct itself as you become more familiar with your routine.

You will need to calculate speed and height "gates" for a number of your manoeuvres particularly those involving pulling or pushing through the downward vertical. Have top out height checks on manoeuvres wherever possible – e.g. at the top of loops, stall turns, pull or push overs etc. The top of these manoeuvres provides time for a quick glance at the altimeter, and four or five such check moments in a sequence gives you a running report on how your energy management is going. They also provide an instantaneous check that you have got room to pull around a particular loop and that you don't need to turn it into a Cuban – especially important in heavy warbirds.

In high performance aerobatics some figures are less certain as to energy content and/or top out height and/or initial recovery heading than others – things like Lomcovaks, torque rolls etc. So don't pile uncertainty onto uncertainty by over complicating these figures: when you've killed the Lomcovak rotation just hit the down vertical and roll to your target line – this is not the time to stick in a knife-edge or flat spin because your starting height and heading is not reliable enough. Instead, do the knife-edge or spin off a stall turn where you had a top-height check and your heading is fixed.

By the same token, never push out of an energy uncertain figure – always pull. Pulling means that you can see where you are going, so if you are a little bit lower than ideal at least you know in time to do something about it.

As you become more experienced so your sequence tends to acquire more action and thereby become more energy tight. This is fine until the day comes when you're hot, high and heavy – suddenly you are using up too much energy. So in conjunction with the height-check points build in 'dump elements' – for example, if you don't see 1,500 ft at the top of a vertical then only do a triple flick on the down 45 line instead of a quadruple – dump one rotation. If you don't see 1,400 ft then only do a double flick: if you don't see 1,300 ft only do one aileron roll **and start worrying about where all the energy has gone.**

Although you will undoubtedly know your sequence off by heart it is a good idea to have a sequence card fixed where you can see it on the instrument panel.

The weather in Northern Europe is such that it is unlikely that you will always have good weather when you display so have a bad weather display planned and practiced to cope with such situations. This may extend to an intermediate rolling routine as well as a flat show.

Wing overs, barrel rolls, half reverse Cubans and stall turns (hammerheads for the colonials) flown at low level are potential killers...

practising for your display

When you are new to display flying you will need to conduct your initial practices at a safe height depending on aircraft type. Remember that aircraft performance at this height may differ significantly from that at sea level and your display will take longer due to this reduced performance.
Once you know the sequence you can start a progressive reduction in your base height. Don't be tempted to immediately go to your display height. Make progressive reductions before adopting a low level display height. You should not be surprised that ground proximity starts to concentrate your mind as you progressively reduce height.

When you are at display height allocate yourself a time on and time off and remember to check the wind and to assess its effect throughout your display.

There may be occasions when you have to display the aircraft at close to maximum all up weight because of the need to carry full fuel, so don't forget to do an occasional practice at maximum display weight. Never fly a display at a greater weight than you have practiced.

In an ideal world all your displays would be flown in perfect weather conditions. The reality is somewhat different. You will need to consider and practice escape manoeuvres for those occasions when you are denied your usual visual references. In general the most sensitive manoeuvres are looping manoeuvres; however, rolling manoeuvres on a day with no clearly defined horizon can be extremely dangerous. If you are in any doubt as to your ability to safely complete a manoeuvre you should abandon that manoeuvre and effect an early recovery.

Remember that engines can and will fail, usually at the most inconvenient moment. Build in the occasional power unit emergency, with plenty of height initially, and have your response prepared.

preparing for your display

As soon as you receive details of the display you should:

Remember that prior to conducting a display you need to be in possession of a valid Display Authorisation and satisfy the recency requirement laid down in CAP 403. Remember that the CAP 403 requirements are a minimum, and it is up to you to ensure that you are properly prepared for your display. Ensure

your own and your aircraft's paperwork are in order.

- Plan the trip including fuel requirements, diversions, en-route and display frequencies etc

- Obtain and prepare appropriately scaled maps and charts including a large scale map of the display venue and its surroundings in order to choose good visual references

- Note your time of arrival and departure, planned diversions, meals, fuel, parking, ground equipment etc

- Check where the proposed crowd line and display area is, as well as any specified avoid areas

- Check whether there will be a rehearsal, and the time it will take place

- Arrange accommodation if you need an overnight stop

- Ensure you have the appropriate kit, spares etc

- Check availability of engineering and ground support, e.g. wing handlers if flying a bi-plane

- Check availability of flight planning facilities, and, if operating from another aerodrome, check its opening hours etc.

plan your transit to the venue, and take into account the following:

- Navigation, probably at low level possibly in less than ideal weather

- Operation at a strange aerodrome or an off aerodrome site

- Non-standard or cluttered R/T

- Arriving at the correct time for your display or letting them know if you can't

- Ensuring that you have sufficient fuel to cater for any unforeseen delays

the air show

at the aerodrome

- Check that the parking arrangements are safe, you don't want your aircraft/other aircraft affected adversely by jet efflux/prop wash/helicopter downwash

- Check that your aircraft is properly chocked and that the controls are locked

- Check that your aircraft is protected from the public by appropriate barriers

- Complete your aircraft turn-around early – fuel may be more difficult to obtain during the display

- Obtain the location and time of the display briefing

- Attend the display briefing

- Confirm the crowd position and the display line/area and plan your display accordingly

- Confirm the display time, whether it is local time or GMT, and establish who will be flying what immediately before and after your slot

- Brief your support personnel

- Prior to start-up do a thorough pre-flight inspection, ensure that your windscreen is clear of insect debris and that there is no crowd debris in the aircraft intakes or vents

- Make sure the taxiways are clear of people, vehicles and rubbish – if necessary, seek assistance with taxiing and ensure the public are not affected by your jet efflux/prop wash/helicopter downwash.

display day

You will have achieved a successful display if you arrive on time, perform without error in the correct place and depart exactly on time. The following preparation will help you to achieve a successful display:

are you fit to fly? – Use the 'I'm Safe' check list:

Illness (any symptom)
Medication (your family doctor may not know you are a pilot)
Stress (upset following an argument)
Alcohol/drugs
Fatigue (good night's sleep etc)
Eating (food keeps blood-sugar levels correct)

display Organisation – make contact with Display Organiser and confirm that his views on your proposed display are the same as yours – you don't want any misunderstandings.

pre-flight checks – get to the aircraft earlier than normal to give yourself sufficient time to cope with the unexpected or a change in display timing. Make sure you do your pre-flight checks methodically (twice).

fuel – your fuel state during the display will be dictated by the distance you have to go after your display – the lower the fuel weight, the better your aircraft will perform but always have a realistic reserve in hand for the unexpected.

density Altitude – remember that high density altitudes caused by a hot day or high altitude aerodrome will adversely affect engine and aircraft performance even in high performance aircraft – high altitude or high temperature or high humidity equals reduced performance.

mental rehearsal – do a mental rehearsal of your display before you get airborne – give yourself an extra 10-15 minutes and use that time firstly to ensure that you and the aircraft are completely ready and secondly that you have a period of quiet reflection on what is coming next – do not get forced into rushing. Walk through the sequence 'flying it' with your hands, thinking about what the wind will do to each and every figure, establishing the pictures you want/expect to see at each figure's start and finish. If conditions are less than perfect establish a mind set where you expect to dump at least some of your dump-elements – it's easier and safer to put them back in on the instant if you have got the parameter, than it is to take them out if you haven't. Then self brief again with your mind on the three most important uncertainties which make each display different from the last – wind, wind and wind, especially on-crowd wind.

functional test – whenever possible, before commencing a display you should give your aircraft a quick functional check at a safe height – check the

Check-six - a mid-air can spoil your entire day not to mention someone else's

engine acceleration, pull your maximum permitted 'g', any services you will use (e.g. airbrakes, flap etc) and do a short inverted run if appropriate.

do your homework – know the local area around your display site either from a large scale map, a recce or local knowledge so that you can arrive at the display on time and correctly aligned.

pre-display checklist – go through your pre-display checklist covering such items as fuel balance, loose articles, altimeter setting, display card and any other item relevant to your particular aircraft.

wind – it is important that you are aware of the latest wind at your operating height, at the display site, and have interpreted it into its components both along the display line and across it – it is a good safe practice to halve the off-crowd wind and double the on-crowd wind. An easy way to forecast the drift in a manoeuvre is to convert half the wind component into metres per second. This is vital when planning the pull-up point of a vertical manoeuvre, especially in a high performance aircraft which has long vertical lines. Here's an example: if you have a 20 kt on-crowd wind component and a 15 sec stall turn, you have 150 metres of on crowd drift during one manoeuvre.

Never commence any rolling manoeuvre at low level without pitching the nose up first.

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other aircraft – be aware that outside and possibly inside the display area it is probably free airspace where all and sundry can freely and legally fly. Keep a good lookout during your pre- and post-display flying as well as during the show itself – be aware of the run-in direction of the next item.

problems – if you have a problem then say so promptly using the correct terminology prefix of Mayday or Pan as appropriate. This will trigger the immediate attention of all on frequency and should get traffic out of the way.

your display – at any show you should be prepared for last minute changes to the time available and hence to the sequence. Never be tempted to make un-rehearsed changes to your display routine and do not undertake any manoeuvres you have not practiced. If you are not happy – abandon the display and land. Better a gap in the display than a smoking hole in the ground. Only shorten your slot at a request from ATC to bring the programme back on time if this can be done at an appropriate point which will not unduly and adversely affect the performance.

If due to an error of judgement or a sudden increase in on-crowd wind component, you are going to bust the required minimum separation distance, it is better to do so rather than risk an overstress or, still worse, a departure

The art of airshow flying is to make the easy look difficult, to make the difficult appear impossible and to leave the impossible well alone...

from controlled flight caused by excessive G close to or over the spectators. As soon as it becomes apparent that a severe overstress or a major bust of the display/crowd line is

inevitable, roll wings level and initiate a climb to ensure that any crossing of this crowd line is under control and at the maximum possible altitude. Remember it is far better to receive a post-flight roasting than a more delayed, but rather final, post-flight cremation.

Stick to your planned routine but always be prepared, particularly at hot and high displays, for reduced aircraft performance. If you don't make your entry parameters for, say a loop it is better to throw it away and substitute a steep turn. Never press on into a manoeuvre with less than ideal start conditions.

post display

Do not relax: your display is not over until the aircraft is on the ground back in dispersal and shut down. Taxiing in at the display site requires the same degree of concentration and care as taxiing out. Don't let the adulation from the crowd distract you from your number one task – getting the aircraft safely on the ground in dispersal, parked, shutdown and with you safely out.

Seek constructive comments from knowledgeable observers.

Whilst the display is still fresh in your own mind review your own performance and make mental or written notes on where improvements can be made.

now you can relax!

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