EGAST
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European General Aviation Safety Team

SAFETY AT FLYING DISPLAYS AND EVENTS: A GUIDE FOR PILOTS

FOR GENERAL AVIATION PILOTS

SAFETY PROMOTION LEAFLET

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CONTENT

Introduction

Flying displays are some of the most popular spectator events in Europe. It is estimated that flying displays and similar events attract over 10 million spectators each year. 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 unfortunate mishaps that have been experienced in the past.

The law

Flight operations for an aviation event are governed by EU safety rules, with some exceptions for historical or military aircraft, which might be excluded from EU safety rules. These rules will apply in most EU Member States by April 2017. Until then national rules apply. In addition, the rules governing how to organise a civil flying display event vary depending on the country of the event and are subject to national rules. There are no European-wide rules on organising a flying display event.

Guidance for display pilots

All flying for displays or events, especially aerobatics, is a specialised form of aviation that frequently involves flying the aircraft close to the edges of the permitted flight envelope. Regrettably, in 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

Personal 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. That applies as much if you are going to fly in one event as if you will fly in many and perform on a regular basis.

Any pilot intending to enter the air display scene fully must have an insatiable desire to fly and be prepared to devote the majority of his/her 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 as you left the house when you are in the middle of your display sequence.

To summarise, make sure that you and your family 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. In some countries, before performing a display in public, you must also hold a valid Display Authorisation or an equivalent document. In addition, major air-displays require that an "air-show/flight safety director approval" is obtained after adequate rehearsal sessions have been passed on the display site.

As far as experience is concerned, it is difficult to specify precisely an 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 and adopt adequate safety gates parameters. Make sure you know your own and your aircraft's capabilities and limitations, particularly the unique characteristics of your aircraft which could catch you out at a crucial moment when flying close to the flight envelope boundaries during your display.

Weather must always be taken into account, and the display profile might need to be adapted to maintain safe clearance from clouds. Even on windy days you must adhere to ground reference lines and safety barriers (the "display line"), so you must plan accordingly.

It is equally important to practise emergency drills and mentally rehearse the ‘what if’ scenarios at various points around your sequence.

Planning your display

Your sequence of manoeuvres, however simple, 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 from an experienced display pilot during your display planning and work-up. For example, a Display Authorisation Evaluator or similar pilot, who is experienced on your type of aircraft, would be ideal. 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:
  - Are well within your own and your aircraft's capability
  - Can be safely flown at low level with established and practised escapes
  - Show your aircraft to its best advantage
  - In aerobatic displays, 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 initial 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.' It is very important that display pilots achieve the positive mind set of Safety First.

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 classic high performance jet fighter has little difficulty sustaining, or regaining, speed and/or altitude during a low level display. The same cannot be said of a traditional piston engined trainer and each requires a different approach when planning a display for such different types.

The overriding factor for an aerobatic display in a low powered aircraft is energy management. There is little point in starting a display with a loop at base height. First, 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 require a crowd line ten kilometres long. You need to know how much airspace your aircraft takes up when performing the various manoeuvres, including positioning.

For example, take a piece of paper and draw a line on it representing a display line. A typical slow roll takes about 10 seconds to perform and this equates to about 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.

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 a formula.

A possible formula for calculating radius of turn is:

Radius (metres) = speed (metres/second) squared divided by 8 times the load factor G.

Using other units, a well known display pilot developed the following:

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

Do not forget you will need something in hand to deal with an on-crowd wind, inaccurate flying or the need to get perfect ground position.

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

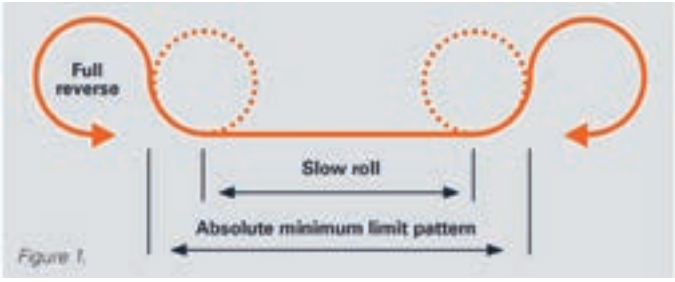


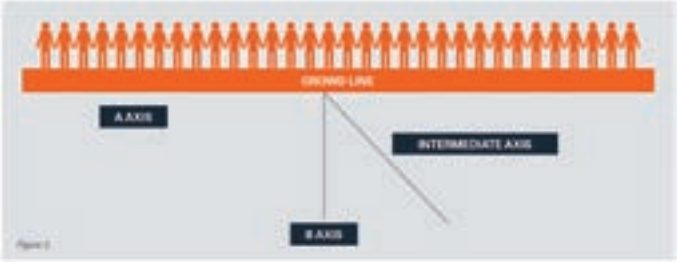
Figure 1.

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 to have flown sufficient practice flights that you can perform your routine without making any major errors in positioning, entry speed and height. That applies to non aerobatic displays as well!

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 pull ups on the B Axis towards the crowd are the most common cause of infringements of the minimum crowd separation distance.



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 leave 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 – including those that are not aerobatic.

Whatever you initially calculated 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.

Generally "safety gates" are adopted to ensure that the aircraft can safely complete an aerobatic manoeuvre. A minimum height above terrain and a maximum Indicated Airspeed must be achieved at the top of a "looping" figure. If these are not achieved, then the manoeuvre must be aborted when it is still safe to do so. Furthermore these "safety gates" must include safety margins based on the pilot experience, the complexity of the airplane and the display profile: the lower the pilot familiarity

with air-displays, the higher the margins! Have top out height checks on manoeuvres wherever possible – e.g. at the top of loops, stall turns (hammerheads), 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 completely round a particular loop and that you don't need to turn it into a half loop and half roll recovery – especially important in heavy war birds.

In aerobatics some manoeuvres are less certain as to energy content and/or top out height and/or initial recovery heading than others – figures like Lomcovaks, torque rolls, etc. Energy concern is vital for all display aeroplanes and a proper sequence of manoeuvres is required. Some extreme aerobatic manoeuvre should be preceded and followed by more conservative ones and should adopt higher safety energy margins.

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 (hammerhead) where you had a top-height check and your heading is fixed.

By the same token, never push out inverted from an energy uncertain figure – always pull into positive flight. 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 always a good idea to have a sequence card fixed where you can see it on the instrument panel.

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

Formation and Tail-chase

Formation flying and tail-chasing are two very different disciplines and should always be treated as such.

Whilst flying in a two aircraft close formation your focus and attention is primarily on your leader. However, a two aircraft tail-chase requires increased situational awareness with a high degree of individual decision making.

Practising for your display

When you are new to display flying, whether aerobatics or not, 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 intended 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 specific time on and time off; 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 practised and try to display at the same 'ideal' weight every time.

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. Also consider the effect of the on-crowd wind component – how would a 30 knot on-crowd wind affect your display? 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.

Find an experienced pilot to watch and critique you, not just how good your display is but how safe. What seems OK to you might be making pilots watching you uneasy. Ask for as much feedback as you can; if you see someone you feel is qualified, seize the opportunity to get them to watch you. If you fly for an organisation with lots of pilots this may be easy to do but, if you operate on your own, consider trying to find a 'mentor' who can occasionally give you critical advice.

If you find you are using most of your ability and skills to perform your sequence, then there's something wrong as you don't have enough spare capacity to cope with things going slightly wrong. How about backing off a little when you feel the pressure is building up? Design your sequence with options you can take if you find things not going well, such as figures you can omit or alternative endings.

Remember...

Engines can and will fail, usually at the most inconvenient moment. Build in the occasional power unit emergency practice, 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:

- 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 areas to avoid
- 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 handling support, e.g. wing handlers for taxying if flying a bi-plane, and the availability of the correct fuel and oil.
- 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 and possibly in less than ideal weather
- Operation at a strange aerodrome or an off aerodrome site
- Non-standard or overcrowded R/T communications

- Arriving at the correct time for your display or letting the organiser know if you cannot
- Ensuring that you have sufficient fuel to cater for any unforeseen delays

Remember...

Prior to participating in a display or other event it is your responsibility to ensure you are properly prepared. Check that you satisfy all the requirements of the European and national safety rules that are in force in the country and location where the airshow or event will take place. Be certain that your own and your aircraft's paperwork and approvals are all in order.

The airshow

At the aerodrome

- Check that the parking arrangements are safe – you don't want your own or other aircraft to be affected adversely by jet efflux/prop wash/helicopter down wash
- 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 yourself
- Confirm the crowd position and the display line/area and plan your display accordingly
- Confirm the exact display time, whether it is local time or UTC, and establish who will be flying which aircraft 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 down wash.

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 the Display Organiser and confirm that his/her 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 anything unexpected or a change in display timing. Make sure you do your pre-flight checks methodically (twice).

Fuel

Your fuel state during the display may 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.

'High altitude or high temperature or high humidity equals reduced performance'

Density altitude

Remember that high density altitudes caused by a hot day or high altitude aerodrome will adversely affect aircraft and engine 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 first to ensure that you and the aircraft are completely ready and second, 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 manoeuvre, establishing the picture you want/expect to see at the start and finish of each one. Imagine looking for ground reference points and how actual conditions will require turns to be anticipated or delayed. Be sure you have memorised the sequence of manoeuvres and its relationship with the reference points.

If conditions are less than perfect, establish a mind set of where in the sequence you expect to use at least some of your dump-elements – it's easier and safer to put them back on the instant you see that you have the necessary 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 beginning a display you should give your aircraft a quick functional check at a safe height – check the engine acceleration, pull your maximum permitted 'g', exercise any services you will use (e.g. air brakes, flap etc.) and do a short inverted run if appropriate.

Do your homework

Learn the local area around your display site either from a large scale map, a reconnaissance 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.

'Keep a good lookout during your pre- and post-display flying as well as during the show itself'

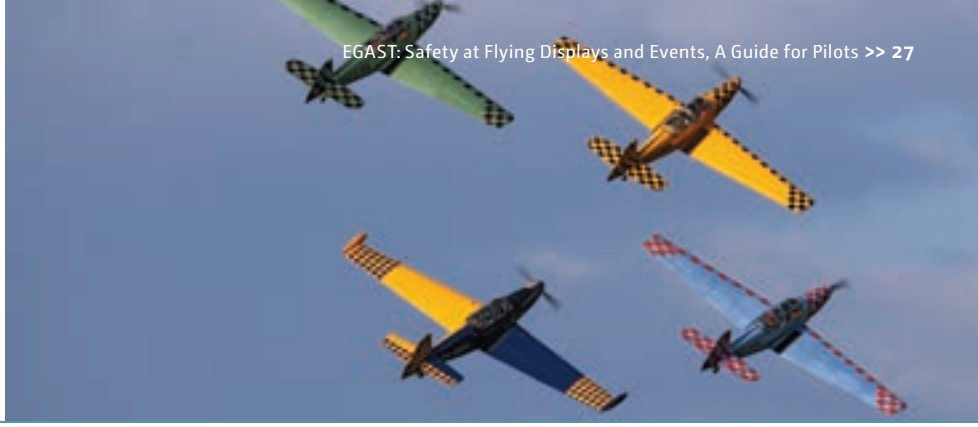
Wind

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 in your mind 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 kts on-crowd wind component and a 15 sec stall turn (hammerhead), you have 150 metres of on crowd drift during one manoeuvre.

Other aircraft

Be aware that outside and possibly inside the display area there is probably free airspace where anyone 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 direction in which the next display item will run in.



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 your sequence. Never be tempted to make unrehearsed changes to your display routine and do not undertake any manoeuvres you have not practised.

If you are not happy – abandon the display and land. Better a gap in the display than a smoking hole in the ground. At a request from ATC to shorten your slot to bring the programme back on time, only do so if you can do it safely at an appropriate point, which will not unduly and adversely affect your 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 safely rather than risk an overstress or, still worse, a departure from controlled flight caused by excessive G close to or over the spectators. As soon as you see 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 from the Flight Director or a Safety Officer 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 completed 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. Do not let the adulation from the crowd distract you from your number one task – getting the aircraft safely on the ground, back in dispersal, parked, shut down 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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European General Aviation Safety Team

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