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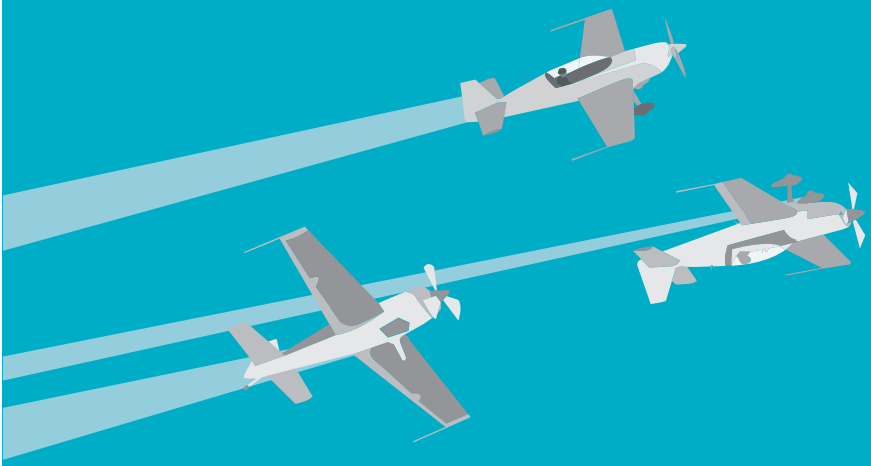
UK Civil Aviation Authority



AEROBATICS IN LIGHT AIRCRAFT

SAFETY SENSE

SS19

YOUR SAFETY SENSE LEAFLET FOR:
AEROBATICS IN LIGHT AIRCRAFT

Aerobatics are an opportunity to explore a new dimension of General Aviation flying.

During training for the initial licence, you are normally exposed to a limited range of aircraft attitudes. Learning aerobatics will involve further exploring the flight envelope, making coordinated use of the aircraft's controls to achieve precise manoeuvres.

Another benefit is the improvement of your aircraft handling skills and increased ability to recognise and recover from unintentional unusual attitudes. Loss of control in VMC remains one of the leading causes of GA accidents.

This SSL is an introduction to the subject and associated best practice. It is not a guide on how to conduct aerobatics or specific manoeuvres. It is important to receive appropriate instruction – a number of accidents have been caused by aerobatic manoeuvres attempted at insufficient height, in unsuitable aircraft or by untrained pilots.

AEROBATICS SSL

Training

The acquisition of skill and knowledge is most effective and enjoyable with high quality instruction. Your basic handling skills acquired during PPL training must be of a good standard before attempting aerobatics. You may have to revise recovery from unusual attitudes.

Full spin recovery is not normally taught on the PPL syllabus, but it should form an early part of aerobatic training. You must be able to recover from unusual attitudes, a poorly executed manoeuvre and incipient or developed spins.

Effective pre-flight briefing is essential to gain the full benefit from any course of training. It is recommended to initially keep aerobatic training sorties short and concentrate on simple manoeuvres, such as loops and barrel rolls. The post-flight analysis and discussion should contribute towards the next session.

You should receive instruction in each new manoeuvre you wish to learn. Attempting to teach yourself may result in an over-stressed aircraft or accident.

As well as learning the individual manoeuvres, you should learn how to conduct an aerobatic flight safely, including aircraft preparation, choosing a suitable location for conduct of aerobatics and safe weather conditions.

Qualifications

You are required to hold an Aerobatic Rating before flying aerobatics as pilot-in-command with a Part-FCL licence. Training for the rating may be conducted at a Declared Training Organisation (DTO) or Approved Training Organisation (ATO).

If flying with a licence issued under the Air Navigation Order 2016, you are not required to hold an Aerobatic Rating, however pilots are strongly recommended to complete a training course with a similar syllabus to that of the Part-FCL Aerobatic Rating.

Flight Instructors (FI) or Class Rating Instructors (CRI) who wish to teach for the Part-FCL Aerobatic Rating are required to:

- Hold an Aerobatic Rating on their Part-FCL licence; and
- Demonstrate competence in teaching the aerobatic rating to a Flight Instructor Course (FIC) instructor.

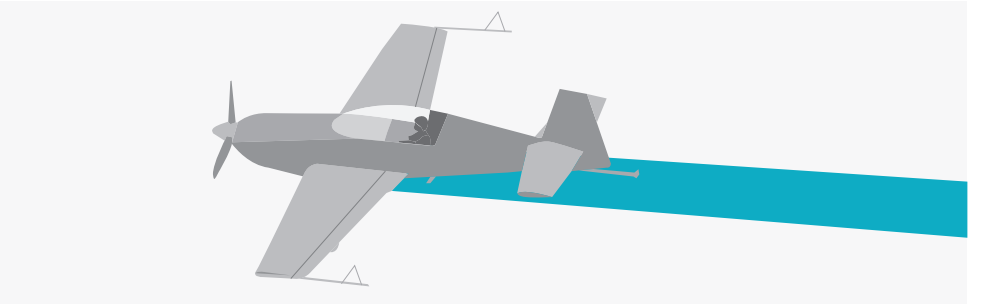
The CAA recommends that instructors complete a training course on how to deliver aerobatic flight training.

The Aircraft Owners and Pilots Association (AOPA) have also published syllabi for three different standards of aerobatic qualification, Basic, Intermediate and Standard.

The AOPA syllabi are taught by various flying schools. The syllabi are also available from the AOPA website for a small fee.

AEROBATICS SSL

Aerobatic Aircraft



It is important to consider aircraft suitability. Within the realm of aerobatic aircraft, there is a vast range in performance and manoeuvrability.

It is possible for a beginner to receive training in an advanced aircraft with a high power to weight ratio and very responsive flight controls, however it may be more beneficial and cost effective to commence on a lower performance platform that is still capable of most manoeuvres.

If there are any aspects concerning the aircraft or its suitability that you do not understand, seek advice from a suitable and knowledgeable person.

Aerobatic Limitations

The aircraft type must be approved for aerobatic manoeuvres. Review the aircraft's Certificate of Airworthiness or Permit to Fly for more information. The Aircraft Flight Manual (AFM) or Pilot's Operating Handbook will also state whether an aircraft is permitted to perform aerobatics and within what limitations. For example, some specific manoeuvres may be prohibited by the AFM.

The aircraft's 'Manoeuvring Speed' (VA) is an important figure to note. Do not apply full deflection of a flight control beyond VA. Ensure you always remain below the aircraft's 'Never exceed' (VNE) speed.

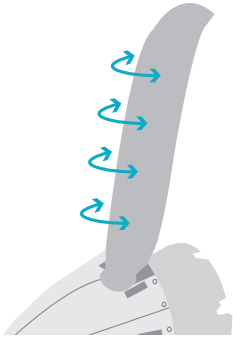
The aircraft will be approved within a certain 'load factor' or 'g-loading' range, specified in 'g'. For example, a typical light aircraft approved for aerobatics will normally have a permitted range of approximately +6g to-3g. The negative g limit is normally lower than the positive limit.

On many aerobatic aircraft the maximum weight and the centre of gravity (CoG) range is more restrictive for aerobatics than normal flight.

The fuel and oil system design may also limit which manoeuvres are possible and the duration for which the aircraft can remain inverted. Some aircraft are only able to remain inverted for short periods, otherwise the engine may be starved of fuel or oil. More advanced aerobatic aircraft are often equipped with 'inverted' fuel and oil systems, allowing inverted flight for longer periods.

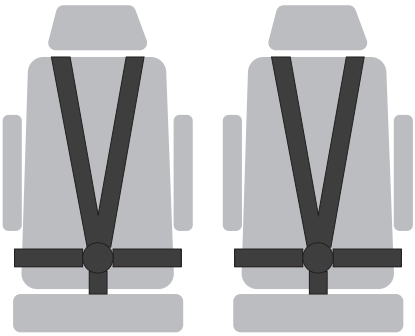
Propellors

Most aerobatic aircraft are equipped with a 'constant speed' propellor, meaning the propellor can maintain a set engine speed (RPM). The propellor hub contains a 'constant speed unit' (CSU) and this uses oil or mechanical spring pressure to automatically vary the pitch of the propellor, accounting for changes in engine power or airspeed. A constant speed propellor is ideal for aerobatics, in which airspeed may change rapidly during manoeuvres.



Some older or more basic aircraft may have a fixed pitched propellor and this means engine speed will tend to increase with airspeed, particularly when descending quickly. Engine speed must thereforebe carefully monitored, and power reduced if required, to ensure engine RPM limits are not exceeded.

Note that most aerobatic aircraft with constant speed propellors are designed to 'fail coarse' in the event of a loss of oil pressure to the constant speed unit (CSU) – the propellor will move to a coarse pitch position, reducing the available RPM. This design is to prevent over-speeding of the propellor and engine, particularly during transient reductions in oil pressure to the CSU. However, it does have the effect of reducing the amount of engine power available, should the CSU experience a total loss of oil pressure.



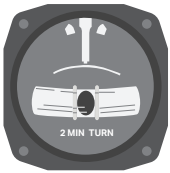
Seat and restraint system

For aerobatics the aircraft must have a full seat harness. A lap belt with a diagonal shoulder strap is acceptable for conducting spinning. Ensure that you understand the system – some aerobatic aircraft have two separate restraint systems.

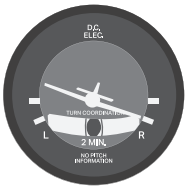
It is important you are seated correctly in the aircraft. Depending on your height or body shape, it may be necessary to sit on a seat cushion to achieve optimum eye height and correct location of the restraint system on the body. Note that some aircraft have a specific weight limit for the seat.

Turn Coordinator vs Turn and Slip

If the aircraft is fitted with a 'Turn Co-ordinator' instrument, be aware that it can give incorrect indications when in an inverted spin. A traditional 'Turn and Slip' indicator will always show the correct yaw direction.



Turn and slip



Turn coordinator

Aircraft Maintenance

If you own the aircraft or are responsible for its airworthiness, maintain a close relationship with the relevant maintenance organisation or Continuing Airworthiness Management Organisation (CAMO). The aircraft maintenance programme (AMP) may need to take account of aerobatic use, such as more frequent inspections of the aircraft structure or flight controls.

The individual or organisation with responsibility for the AMP should check whether the Design Approval Holder (DAH) has any specific continuing instructions or recommendations relating to aerobatic use. If the aircraft is managed by a CAMO, ensure they are aware of aerobatic use when the AMP is compiled.

Amateur built or other aircraft that fly in accordance with a Permit to Fly may not have a formal AMP, however the engineer or whoever maintains the aircraft should be familiar with the type and any critical areas to inspect, particularly when the aircraft is used for aerobatics.

If you are hiring the aircraft from a flight school or private individual, it is appropriate to ask what airworthiness arrangements are in place and to what extent they reflect aerobatic use.

Human factors

Attitudes and behaviours

It is important to approach aerobatics with a professional attitude. The nature of the activity means training and self-discipline is required to ensure you always stay within safe parameters. Aspire to fly with precision – know the correct heights and speeds for each manoeuvre and respect the limitations established for your level of skill and experience. Avoid the temptation to 'push the boundaries' or attempt manoeuvres at altitudes lower than set in training.

Even conscientious pilots may sometimes take risks in a dynamic situation that with more opportunity to analyse, they might recognise as hazardous. You must therefore rely on good training and attitudes from the outset, such that you default to the safe option. Anyone can be affected in the 'heat of the moment', but anticipation will reduce the risk.

Be aware of:

- Pushing through manoeuvres despite not entering or progressing them correctly. If a manoeuvre is not initiated correctly, make an early decision to exit rather than pushing on and hoping that it will be successful; and
- A temptation to exceed limitations such as conducting untrained manoeuvres or at a lower height than set in training – this can occur if complacency or overconfidence develops.

Accidents have occurred through people 'showing off' at aerodromes or in front of friends and relatives. Aerobatic display pilots are specially trained to deal with the risks associated with flying in front of an audience. Do not be tempted to 'display' to people on an unplanned basis or without the proper qualifications.

Hazardous attitudes

Human factors analysis has identified five 'hazardous attitudes' which pilots may be influenced by. Being aware of these and the associated 'antidote' belief will reduce the associated risks.

Summary of hazardous attitudes:

Name	Description	Antidote
Anti-authority	*"Don't tell me..."*	Follow the rules; they're usually right.
Impulsivity	*"Do something quickly!"*	Not so fast-Think first!
Invulnerbility	*"It won't happen to me..."*	It could happen to me!
Macho	*"I can do it"*	Taking chances is foolish.
Resignation	*"What's the use"*	I'm not helpless.

For more information, see the Skyway Code section on GA risks.

Your personal limitations will broaden as your training progresses. Confidence in your abilities is desirable, however you should also maintain a healthy degree of self-critique and not become overconfident or take the activity for granted. You should aim for continuous improvement within the framework of training and rules.

Fit to fly

Aerobatics places a physiological toll on the body and being fit to fly is very important. **IAM SAFE** is a good mnemonic for assessing your physical and mental state:

I — **Illness**
Do I have any symptoms that might affect my ability to fly?

A — **Attitude**
Am I emotionally ready and fully focussed on the flight?

M — **Medication**
Am I taking any prescription or over-the-counter drugs that might affect my performance?

S — **Stress**
Am I under pressure or have any worries and anxieties?

A — **Alcohol**
Have I been drinking within the last 24 hours?[1]

F — **Fatigue**
Am I tired or not adequately rested?

E — **Eating**
Am I adequately nourished?

An important practical step is to ensure you can focus on the flight and are not distracted by factors that may reduce your mental capacity. Give yourself time to prepare for each flight and review any issues or learning points from previous sessions. Adopt a mindset of continuous improvement.

Spatial disorientation

Aerobatic manoeuvres involving significant changes of aircraft attitude and will therefore affect the balance apparatus of the inner ear. In the absence of clear visual cues, erroneous information regarding balance may be transmitted by the inner ear to the brain. This may lead to disorientation, so a good horizon and visibility are essential for conducting aerobatics.

[1]You must not fly within 8 hours of consuming alcohol. Significant quantities of alcohol may take 24 hours to exit the body. The legal blood/alcohol limit for aviation is 20 mg/100 ml- note this is a quarter of the limit for driving in England and Wales.

Motion sickness

Even with good visibility, it is possible to suffer motion sickness caused by the mismatch between internal balance cues (which suffer a time lag) and the visual information coming from the eyes. The feeling of motion sickness will normally decrease with greater experience of conducting aerobatics.

Passengers with limited exposure to aerobatics may experience motion sickness. You should warn this might happen but explain that it is a normal physiological response. Ask passengers to inform you if they feel unwell. Becoming pale and quiet is another indication that someone may be experiencing motion sickness. Always carry sick bags and inform passengers of their location and use.

Particularly if a passenger is experiencing aerobatics for the first time, keep the flight short and discontinue manoeuvres if they feel unwell. The feeling of sickness may persist until back on the ground, so be prepared to return to the aerodrome earlier than anticipated.

Effects of g-loading

During aerobatics, 'g-loading' causes shifts of blood within the body. Positive 'g' moves blood toward the feet and away from the brain. At around +3.5g to +4g a relaxed human being will suffer vision changes, initially loss of colour and peripheral detail, known as 'greyout'. Depending on the length of exposure, a complete loss of sight may then occur – 'blackout'. Higher loadings for a sustained period will cause loss of consciousness – 'g-loc'.

Tensing the stomach and leg muscles and making a grunting sound will increase the loading the body is able to sustain without losing vison or consciousness. Guidance should be sought from a pilot who is familiar with the technique, and this should form part of aerobatic training. With experience and practice of the correct technique, the body's resistance to the effects of g-loading can be significantly increased.

Passengers should also be advised to adopt the muscle tensing technique. Also advise them to keep the head still as much as possible, since this will minimise the risk of neck injuries and reduce the feeling of disorientation.

Negative g manoeuvres cause blood to accumulate in the head and the increased blood pressure may cause damage. Little can be done to mitigate the effects of negative g, which is poorly tolerated by the human body.

A person's tolerance to g-loading tends to increase with exposure but reduce with age. Compared to normal flight, aerobatics places higher stress on the body. You should seek advice from an Aeromedical Medical Examiner (AME), particularly if over the age of 60 or if you suffer from any medical conditions.

Restricted Body Movement

With the trajectory of the aircraft changing rapidly during manoeuvres, it is important that pilots can conduct an effective look-out scan in all directions. If you have any condition or injury (for example to the neck) which restricts your ability to move your head while looking out, discuss this with your instructor and establish what the impact may be. Some conditions or injuries may restrict or prevent you from conducting aerobatics.

Protective equipment

There is no legal requirement to wear or use specific garments or equipment when conducting aerobatics. However, the following items are recommended:

Gloves protect against fire and abrasion in an accident. They also avoid perspiration being transferred to the control column, improving grip.

A flying suit made from natural fibers, with zippered pockets and close-fitting ankles. The suit will provide some protection from fire and allow you to store miscellaneous items such as pens or small charts, preventing them from coming loose in the cockpit.

Particularly in open cockpits, a lightweight helmet gives protection while minimising discomfort under increased g loadings.

Footwear that is close fitting and comfortable. The sole of the footwear should be reasonably thin to allow good feel of the rudder pedals. You may find a boot similar to that used in motor racing to be ideal.

A parachute enables escape from the aircraft if you are unable to recover from a manoeuvre. If a parachute is worn, be familiar with its operation and regularly rehearse how to abandon the aircraft safely. Consider a static line deployment system to save time. A parachute should be comfortable and well-fitting, with surplus webbing tucked away. Ensure the parachute is maintained in accordance with the manufacturer's instructions.

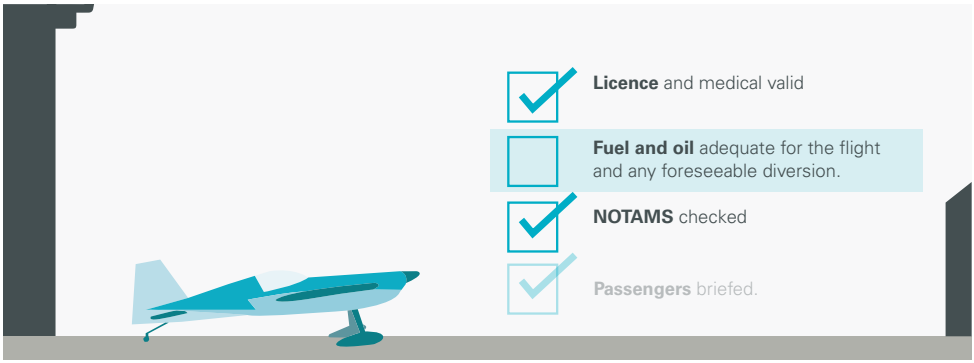
For the carriage of a parachute to be an effective safety net, you need to set a hard height below which you will abandon the aircraft. Consider the minimum height you have set for your aerobatics and how much height is needed to exit the aircraft and deploy the parachute.

Nutrition

Eating a healthy and moderate meal a few hours prior to an aerobatic flight is normally beneficial. Avoid heavy foods or eating immediately prior to a flight. However, it is not recommended to have a long period prior to the flight without food – this will increase the likelihood of feeling motion sickness. Lack of nourishment will also reduce your concentration and tolerance to g-loading. Explain this guidance to any passengers prior to the flight.

AEROBATICS SSL

Pre-flight preparation



Planning

Use threat and management as you would for any other flight. Aerobatics usually requires good weather conditions, so establish what criteria are necessary for the flight to go ahead. Allow plenty of height from ground to cloud base. Recognition and recovery from an inadvertent spin and the subsequent dive may require many hundreds of feet- for example, a Chipmunk requires 250ft per turn and 1,200ft for the dive recovery.

Aircraft with a low power-to-weight ratio often need to lose height during a sequence, so if applicable, account for this when considering the margin above your base height.

Consider the area in which you are planning to conduct aerobatics. It should generally be away from congested areas and potential airspace hazards.

Be considerate to those on the ground and vary the areas in which you conduct your practice. Aerobatics performed in one place for any significant period will cause more disturbance than a normal passing aircraft. Avoid regular VFR routes and areas well known to have frequent traffic, such as near aerodromes that have a lot of flight training activity.

Weight & Balance

Ensure fuel load is optimal for the flight. Check that you will remain within the permitted weight and balance envelope, both for take-off and landing. Often the permitted centre of gravity range and maximum take-off weight is more limited for aerobatics than normal flight. Attempting aerobatics outside the aerobatic weight and balance envelope may result in insufficient control authority during manoeuvres or structural damage to the aircraft.

Pre-flight checks

The pre-flight inspection needs to be carried out with extra care, since the aircraft will be flown closer to its structural and performance limits. Ensure you understand any type-specific components that need scrutiny in the pre-flight check.

Check that all items of cockpit equipment, such as seat cushions and the fire extinguisher, are properly secured.

Ensure there are no loose items in the cockpit, such as pens, charts or USB cables. Heavier items such as keys or phones should be left behind or placed in a secure storage compartment. Even the most insignificant object could lodge in the flight controls and restrict movement. Under negative g-loading, any significant dust or dirt from the floor will rise inside the cockpit and may enter your eyes.

Ensure you are comfortable in the seat and firmly strapped in. The seat harness should feel tight but not cause discomfort. You should be able to operate all the controls to their full travel without difficulty and reach all relevant cockpit switches and instruments. It is essential that you feel part of the aircraft and not a loose object within it. Any significant surplus of the harness straps should be secured.

Unless installed or mounted in a manner acceptable for aerobatic flight, portable VFR moving map devices or cameras should not be present in the cockpit.

Check that all flight controls, including the rudder, have full travel. The ability to apply full travel on the rudder is particularly important for spin recovery. If equipped with nosewheel steering, it may be necessary for the aircraft to be moving before performing the rudder check.

In flight

Rules of the Air

Always comply with the Rules of the Air, as set out in the UK Standardised Rules of the Air (UK SERA) and the Rules of the Air Regulations 2015. For more details, see the Skyway Code.

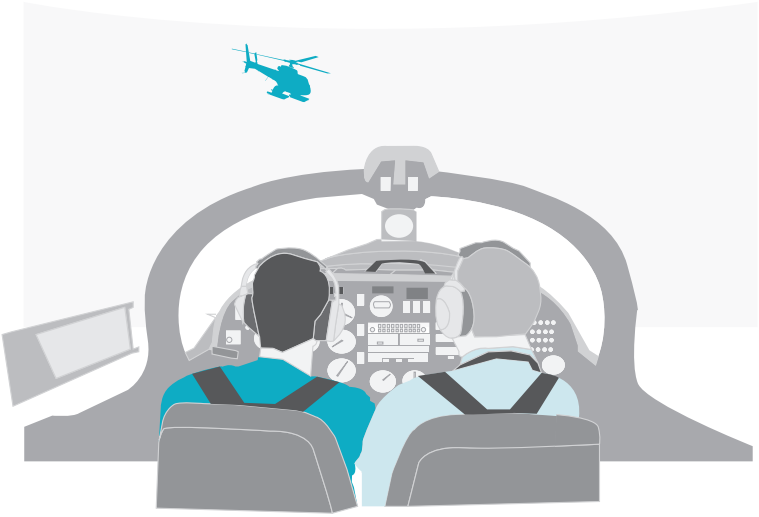
Note that Rule 4 of the Rules of the Air Regulations 2015 prohibits aerobatic flight over the congested area of any city, town or settlement. Aerobatic flight in controlled airspace must always be approved by the relevant air traffic control unit.

Transponder use

7004 is allocated as an SSR code for aircraft conducting aerobatics, to assist the situational awareness of nearby air traffic service units. Set the code five minutes prior to commencing and ensure 'ALT' mode is enabled on your transponder. If there is a Lower Airspace Radar Service (LARS) unit in the area, consider obtaining a UK Flight Information Service (FIS).

Lookout

Maintain an effective lookout throughout the flight. Guidance on the visual scan is available in the Skyway Code and SSL 13, Collision Avoidance. During actual manoeuvres the ability to look out is reduced, so it is important to do so extensively before and after.



Pre aerobatic checks

Assess whether the actual cloud and visibility are sufficient in the area you intend to conduct aerobatics. There should be a clear horizon all around.

Always conduct a **'HASELL'** or similar check prior to commencing aerobatics:

- **Height -** depends on experience of pilot, but novices should commence at no less than 5,000 ft above ground level (AGL) and all manoeuvres should be completed by 3,000 ft AGL.
- **Airframe -** flaps up, brakes off (in some aircraft brake application restricts rudder movement), wheels up, etc. (refer to the aircraft flight manual).
- **Security -** harnesses fastened, canopy/doors secure and no loose articles.
- **Engine -** engine instruments reading normally, mixture rich, carb heat check, adequate fuel selected and electric fuel pump on if applicable.
- **Location -** clear of congested areas and outside or remaining below any controlled airspace (unless appropriate permission from the controlling ATC unit has been given). An area offering forced landing options in the event of engine problems is wise. Note a good landmark to assist orientation.
- **Look-out -** clearing turns in both directions and check above and below the aircraft.

Between sequences of manoeuvres this check may be abbreviated to **'HELL',** assuming you have not changed the configuration of the aircraft.

Maintain a continuous look out as much as practicable – during manoeuvres you generally need to focus on the horizon or specific parts of the aircraft, but always look around at the beginning and end.

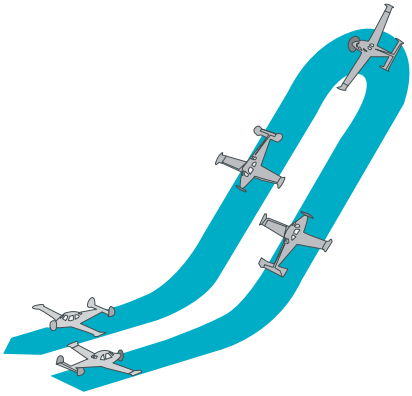
HELL

Height

Engine

Location

Look-out



AEROBATICS SSL

Maintaining skills and knowledge

There are no revalidation or renewal requirements for the Aerobatic Rating. However, if you have not flown an aerobatic flight for some time the CAA recommends you receive refresher training from an instructor.

Once you have achieved a certain level of aerobatic proficiency, you may wish to simply enjoy your new skill. It is important to stick to the framework you have been taught and maintain self-discipline in planning and executing flights. Stick to your minima for recovery height and weather conditions.

Ensure you can always recall recovery actions from different unusual attitudes and failed manoeuvres – for example it is normally safer to roll to the nearest horizon, rather than continuing to pull when there may not be sufficient energy.

Mentally rehearse the spin recovery, both erect and inverted. If you ever fly a different aircraft, ensure you know the spin recovery procedure – this should be included in any aerobatic type conversion instruction.

If you wish to try more advanced aircraft or manoeuvres, seek appropriate instruction.

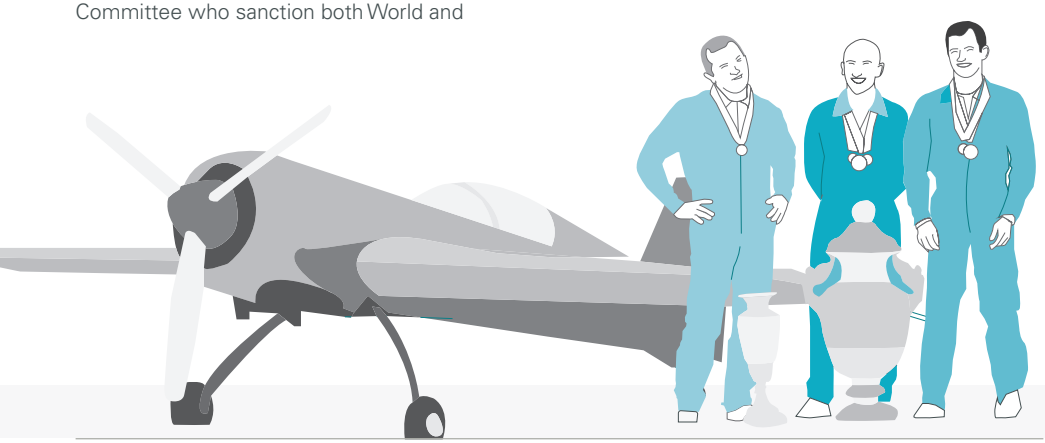
Competitions

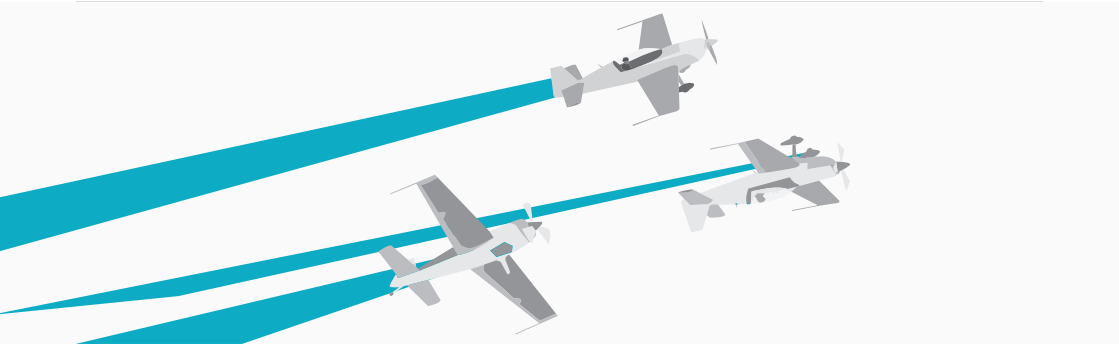
Once the basic skills have been mastered, many pilots are quite content with the occasional aerobatic flight in a club aircraft to enhance their pleasures of aviation.

However, some pilots enter competitions to measure their ability against others at a similar level of attainment.

Competition aerobatics is an international sport under the Federation Aeronautique Internationale (FAI). The relevant sporting regulations have been prepared by the International Aerobatics Committee who sanction both World and Continental championships. The Royal Aero Club of the United Kingdom recognise the British Aerobatic Association as the sport's representative body to foster development and to organise national competitions.

Contests are held at different levels of pilot skill – these are Beginners, Standard, Intermediate, Advanced and Unlimited. Aircraft performance is a major factor in progression up the levels; however, a well-flown sequence in a basic aircraft can still be competitive.





Flying displays

Before a pilot is permitted to perform aerobatics at a public or private Flying Display, or any public event, he or she must have a Display Authorisation (DA) permitting aerobatics issued by the CAA. See CAP 1724- Flying Display Pilot Authorisation and Evaluation: Requirements and Guidance for details on obtaining or upgrading a DA.

The pilot must confirm that the event is organised and supervised by either a Flying Display Director or an Airborne Flying Display Director, and that a permission for the flying display has been obtained from the CAA.

Pilots are strongly advised to consult the latest version of the Air Navigation Order 2016 (Article 86) and CAP 403 – Flying Displays and Special Events: a Guide to Safety and Administrative Arrangements, for the detailed requirements associated with hosting a Flying Display.

SUMMARY

- Receive appropriate instruction before attempting aerobatics
- Observe the right attitudes and behaviours
- Select a suitable aircraft
- Be proficient with recoveries from spins and unusual attitudes
- Know the escape route for each manoeuvre
- Define your minimum recovery height and monitor constantly
- Maintain a good look-out
- Remain within AFM limitations.