

UK-CAA POLICY FOR LIGHT UAV SYSTEMS



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ABSTRACT

UK Policy for the certification and operation of UAV Systems, both military and civil, was first published in CAP722 [1] in May 2002. Under this policy, the principles established for civil manned aircraft are extended to civil UAV systems, including the need for system to be certificated to a code of airworthiness and organisations involved in the design, manufacture, maintenance or operation of a civil UAV system to be approved for the purpose.

Since publishing CAP722, the CAA has further reviewed and developed its UAV policy, both in the light of recent experiences and as a result of changes in regulatory responsibilities since the formation of the European Aviation Safety Agency (EASA). The regulations governing civil UAV Systems below 150kg have in particular been targeted in this review, as the responsibility for both airworthiness and operations remains vested with national aviation authorities. The CAA also recognised that this category of UAV has potential for early applications, and yet may find difficulty in complying with the principles of CAP722.

To address civil light UAV Systems, the UK CAA has developed a new policy, and it is this policy that is the subject of this paper. The UK Light UAV Systems Policy will ensure that acceptable safety standards are maintained whilst providing a route for the routine operation of light civil UAV Systems. Exemptions to UK national regulations may be granted to civil UAV Systems that can demonstrate compliance

with the policy and show equivalence in terms of safety risk to existing model aircraft. Not all civil UAVs below 150kg will meet the applicability criteria or qualify for an exemption under the Light UAV Systems policy. For those UAVs, the general policy contained in CAP722 will still apply.

1. INTRODUCTION

The ability of civil Unmanned Aerial Vehicles (UAVs) to integrate with manned aircraft and operate routinely in the open airspace, currently presents significant technical difficulties which have yet to be resolved (e.g. the provision of an adequate "Sense & Avoid" capability). Until the solutions to such problems are available and UAVs can achieve parity with manned aircraft in respect of freedom of operation, civil UAVs are likely to be operationally constrained and segregated from manned aircraft.

A prediction of how the civil UAV Systems market is likely to grow [2] has highlighted three possible areas, identified in terms of aircraft mass and altitude capability. These include: High Altitude Long Endurance (HALE) operations; medium altitude applications primarily based on existing military platforms; and local range operations at low altitude using light UAVs primarily for visual inspection and incorporating highly miniaturised payloads. Of these potential growth areas, the one least affected by the technological constraints is local range operations and applications in this area are already

beginning to emerge. A survey of existing UAV Systems worldwide [3] has indicated that a large proportion (79%) of those employed in purely civil, research, or dual-purpose operations (military & civil) are aimed at this market segment and that this trend is likely to continue for the foreseeable future.

In the light of this knowledge, the UK-CAA has undertaken a review of its existing UAV Systems policy to determine whether provisions could be made to better enable Light UAV Systems to operate and remove any unnecessary regulatory burden. This review was based on the realisation that light aircraft used in local range operations are not unique to UAV Systems. Pilotless aircraft in the form of “model aircraft” have been flying successfully for many years and have achieved an acceptable safety record. Furthermore, in the past these model aircraft have, on a case-by-case basis and subject to certain operating constraints, been allowed to operate commercially in performing Aerial Work tasks – effectively operating as UAVs.

This Paper describes the existing regulations for model aircraft and how the CAA has developed these to arrive at the UK Light UAV Systems policy. This Paper also details the applicability criteria and operational constraints imposed on UAV Systems to be eligible for exemptions to UK national legislation under this Light UAV Systems policy.

The UK-CAA Light UAV Systems policy has been proposed and accepted by the JAA/EUROCONTROL Task Force as a basis for guidelines for the regulation of light UAV Systems within the European Union [4].

2. APPLICABILITY

To ensure that overall safety standards are maintained, applicability of the UK-CAA Light UAV Systems policy is limited to civil UAV systems that have no greater capability than existing model aircraft and which are subject to similar operational limitations and conditions. Equivalent safety standards are established by

addressing both the risk to 3rd parties on the ground (measured in terms of the UAV’s kinetic energy on impact) and the risk to other airspace users (through compliance with the Rules-of-the-Air and avoidance of aerial collisions).

A UAV System eligible for consideration under this policy must consist of an air vehicle with a maximum kinetic energy on impact not exceeding 95KJ (as determined from 2 crash scenarios discussed later in this paper), a maximum take-off mass below 150kg and a maximum sustained speed in level flight not exceeding 70kts. Operational constraints include line-of-sight operation at a range not exceeding 500 metres from the UAV-pilot and at a height not exceeding 400ft above ground level. The justification for these limitations is described further in this paper.

It should be noted that one new external constraint on CAA policy is that EASA legislation [5] makes it clear that, except for UAVs specifically designed or modified for research, experimental or scientific purposes and likely to be built in small numbers, and UAVs operated by the police or similar services, national procedures will only apply to UAVs of up to 150kg mass. Policy for the regulation of most UAVs above 150kg will be determined by EASA.

This policy is applicable to all types of UAV Systems, including those of novel design. UAVs under 7kg mass fall within the Small Aircraft definition of the Air Navigation Order (ANO) [6] and are exempt from most regulatory provisions. Such UAV Systems are currently the subject of a further review by the UK-CAA and may be included within this policy at a later date.

3. EXISTING REGULATORY ENVIRONMENT FOR MODEL AIRCRAFT

UK national regulations for model aircraft are summarised in CAP 658 “Model Aircraft: A Guide to Safe Flying” [7]. Under the terms of the regulations, Small Aircraft less than 20kg are excluded from the vast majority of the regulations that apply to other aircraft. The regulations provide freedom to operate a Small Aircraft

provided the operator does not act in a reckless or negligent manner so as to endanger any person or property.

For Small Aircraft with mass between 7kg–20kg, some additional operational constraints are imposed to ensure adequate safety. These include:

- Clear of controlled airspace, unless with ATC permission,
- Clear of any aerodrome traffic zone, unless with ATC permission
- At less than 400ft above the point of launch, except with permission as above,
- Within 500 metres of the operator at all times.
- Not within 150 metres of any congested area of a city, town or settlement,
- At least 50m clear of persons, vessels, vehicles or structures. This can be reduced to 30m for take-off or landing. Other model operators and any assistants or officials may be within this distance; as may vessels, vehicles or structures under their control,
- A serviceable “fail-safe” mechanism shall be incorporated to terminate the flight following loss of signal or detection of an interfering signal,
- Ensure that any load carried on the model is secure,
- Flights must comply with any conditions such as byelaws,
- CAA permission is required for any commercial flights.

Restricting the height of a model to 400ft minimises potential conflicts with other aircraft. Flight within 500 metres of the operator at all times is imposed both to ensure correct handling of the model and also to ensure that the operator can perform the “see and avoid” function necessary for the avoidance of aerial collisions. In order to adequately perform the “see and avoid” function, it is essential that the model flyer continuously monitors the model and the airspace both around and sufficiently beyond the model in order to anticipate potential collision risks and have sufficient time to take avoiding action. The final constraint is added in recognition that models used for commercial activities

are likely to be operated close to persons and property, rather than at a remote model flying site and may therefore constitute a greater hazard to 3rd parties and property.

In addition to the regulations for Small Aircraft, for many years the UK-CAA has issued exemptions from most provisions of UK national regulation for larger model aircraft that fall outside the definition of a Small Aircraft. Whilst these exemptions have included relief from the need to comply with airworthiness certification requirements, the granting of the exemption has been conditional upon the CAA being satisfied that the model is designed and built to a satisfactory standard and that operational controls are in place, including the choice of a suitable rural site to preserve adequate separation between the aircraft and 3rd parties, and flight is undertaken under the ‘control’ of a recognised model association.

For existing large models, the CAA has been satisfied regarding the design and build standards on the basis of recommendations provided by the Large Model Association (LMA), an organisation recognised by the CAA as providing expertise in this field. The process for recommending acceptance starts with the LMA inspecting an aircraft during construction and satisfying itself that it has suitable integrity of design and construction as represented by accepted good practice. Then, following the granting by the CAA of an “exemption for flight testing”, the LMA will oversee a programme of “function and reliability” flight trials (at least 6 flights totalling at least 1 hour for each named pilot). When satisfied that the aircraft has completed this testing without modification or mishap the LMA will normally provide a positive recommendation to the CAA that a renewable exemption should be issued.

4. POLICY FOR LIGHT UAV SYSTEMS

As model aircraft operations have been conducted in an adequately safe manner for many years with no airworthiness requirements in place for those below 20kg mass, and LMA oversight for heavier aircraft, the CAA has concluded that UAV

Systems that are “equivalent” to existing model aircraft and have no greater capability, may be allowed to operate without obtaining airworthiness certification, subject to the UAV System complying with similar limitations and conditions to those applied to model aircraft.

To provide a measure of “equivalence”, the regulatory concept developed here uses impact kinetic energy as a basic criterion. Impact kinetic energy is directly linked to the ability of a UAV to cause damage and injury. It provides both an absolute measure for the showing of compliance and a relative standard for identifying “equivalence” with model aircraft. Kinetic energy is also an all-encompassing criterion applicable to all aircraft type, is easy to determine and can be readily estimated during the design process. To maintain comparability with models in other respects, the UAV System will be subject to design, construction, and flight testing scrutiny at least as demanding as that carried out for large models by the LMA.

A key feature of the involvement of the LMA in the safety of large models is their requirement for “function & reliability” flight testing of significant duration. It is considered that it is this activity that provides, in the absence of formal requirements, the necessary safeguards against the presence of poor stability, control and performance characteristics.

Under these provisions, a Light UAV may be granted the necessary permission and exemption to operate commercially in the vicinity of persons and property, (subject to defined minimum separation distances). To protect these persons and property, it is appropriate to set a safety level somewhat higher than that associated with recreational flying. Also, it is recognised that any flight assessment must be essentially qualitative, and therefore it is considered prudent to supplement the assurance gained through the “function & reliability” testing with some additional quantitative constraints to address the possible consequences of poor handling qualities.

The proposed additional constraints are as follows:

- a. A Light UAV will not be granted an exemption, regardless of its mass, if the maximum speed it can sustain in level flight exceeds 70kts. This addresses the issue of higher pilot workload inherent in operating at higher speeds, (a problem that increases as aircraft size reduces), and also supports the maintenance of separation from 3rd parties. i.e. In common with model aircraft exemptions, those issued for Light UAV Systems will specify minimum acceptable separation distances from 3rd parties and their property. Imposing the 70kts limitation should provide a reasonable time period for the pilot to take recovery action in the event of his UAV unexpectedly heading towards a 3rd party. (Note - It is envisaged that compliance with this speed limitation will be demonstrated during flight testing by flying the UAV straight and level at full power and measuring the steady velocity achieved).
- b. To reduce the possibility of a high kinetic energy impact following loss of control, aerobatics will be prohibited.
- c. The conditions of the exemptions will prohibit tasks that involve aerial inspection of, or close to, any object or installation that would present a risk to safety in the event of damage due to any impact by the UAV. (e.g. Chemical/gas storage areas).
- d. The conditions of the exemptions will prohibit participation in any public flying display, (except with the written permission of the CAA).

5. SETTING KINETIC ENERGY LIMITS

To maintain “equivalence” with the model aircraft fleet, kinetic energy limits are established based on a philosophy previously developed by the CAA and detailed in CAA Paper “Aircraft Airworthiness Certification Standards for Civil UAVs” [8]. That CAA Paper

presented comparisons of the kinetic energies for a range of aircraft for two scenarios - i) an emergency landing under control, and ii) complete loss of control. In the case of Light UAVs that are constrained to operate at a maximum height of 400ft, it was considered to be more appropriate to select two scenarios: a free-fall from 400ft for all UAVs and, additionally, for UAV capable of high forward speed (e.g. all fixed-wing aircraft), a maximum impact speed (set as 1.4 x maximum operating speed). Note that the "free-fall" scenario is intended to address descent of the aircraft out of control, due to failures of primary structure or critical systems. Examples of such failures for a rotorcraft would be the unrecoverable loss of main rotor speed, or separation of a main rotor. For a lighter-than-air aircraft such failures could include the rupture or complete separation of the gas envelope.

To set the maximum kinetic energy limit, the CAA reviewed its current experience with models and UAV Systems. Requests to the CAA for permission to carry out Aerial Work with line-of-sight model aircraft/UAVs to date have been for aircraft in the mass range 7kg to 60kg. It was also noted that around 80 of the 85 large models operating under exemptions are in the range 20kg to 75kg. Allowing UAVs to operate up to a mass of 75kg was therefore considered appropriate as it incorporated all of the existing Aerial Work model aircraft, with some growth potential, and was comparable with the majority of the existing large model fleet.

The 70kts maximum level speed specified above, combined with a mass of 75kg, provides a calculated kinetic energy of 95KJ for the 1.4 x V_{max} scenario. To ensure that the ability of the UAV to cause damage or harm is constrained no matter what the circumstances of the crash or the characteristics of the UAV, this value of kinetic energy was also stipulated as the maximum for the free-fall scenario. A single kinetic energy limit was therefore stipulated which a Light UAV System must not exceed when assessed against both impact scenarios. A UAV with a maximum speed below 70kts would be permitted to have a correspondingly higher mass provided the same kinetic energy limit was observed.

Assuming negligible aerodynamic drag, an object dropped from 400ft will hit the surface at 95kts and the kinetic energy at impact will be 95KJ if the mass of the object is 80Kg. Should the object in fact exhibit significant aerodynamic drag, (without reliance upon any onboard parachute deployment system), the impact velocity will be less and so higher mass may be permissible without exceeding a calculated 95KJ impact energy for a free-fall from 400ft.

Examples of the mass and speed combinations that fall within these criteria are given in Appendix 1.

6. AN ACCREDITED BODY TO MAKE RECOMMENDATIONS

The LMA has advised the CAA that it exists for the benefit of recreational model aircraft enthusiasts only, and will not support commercial UAV Systems. Consequently, it will be necessary to establish a body of similar competence to the LMA that will be able to provide similar recommendations on the basis of procedures acceptable to the CAA.

In the absence of such a recognised body, the CAA has in the past accepted assurances given by a learned body with aeronautical engineering expertise, such as a University Aeronautical Department, in lieu of a recommendation. Until such time as an accredited body is established, the CAA may, on an ad-hoc basis, assess each application, taking into account the experience and knowledge of the applicant/operator in lieu of a recommendation, provided it can be assured that the standards applied are at least as demanding as those applied by the LMA.

7. ISSUE OF EXEMPTION

It is proposed that a Light UAV System complying with these criteria should be eligible for an exemption from the airworthiness certification requirements stipulated in UK legislation, and that the

wording of the document granting such an exemption would include the same conditions and limitations specified by the document currently issued to large models, but with the addition of the items listed as b, c, and d in Section 4. Appendix 2 gives a first draft proposal for such an exemption document.

UAV Systems that do not comply with the applicability criteria or operate outside of the constraints imposed, including beyond 500 metres from the UAV-pilot, will not be eligible for exemption and will therefore be subject to formal airworthiness certification in accordance with the previously UK-CAA published policy.

8. CONCLUSION

UK-CAA policy covering the operation of Light UAV Systems in UK airspace has been developed to facilitate the UAV industry while providing acceptable conditions for safe operation similar to those applied to model aircraft. Light UAV Systems that meet the applicability criteria and can operate within the constraints identified above will be eligible for a conditional exemption against parts of existing UK regulation as detailed in the example exemption contained in Appendix 2.

The UAV System must be the subject of a positive recommendation from an accredited body giving assurance of acceptable design and build standards, and of the completion of an appropriate function and reliability flight test programme without incident or modification. In the absence of such a body, the CAA will make an assessment of the above standards, taking into account the experience and knowledge of the applicant.

9. REFERENCES

1. CAP 722: Unmanned Aerial Vehicles Operations in UK Airspace – Guidance May 2002
(Available on the CAA Website (www.caa.co.uk/docs/33/CAP722.pdf)).
2. JAA/EUROCONTROL UAV Task-Force Final report. Main Body – Section 2.2
3. JAA/EUROCONTROL UAV Task-Force Final report. Enclosure 3 Appendix WG II-1
4. JAA/EUROCONTROL UAV Task-Force Final report. Annex 1.
5. Regulation (EC) No 1592/2002 of the European Parliament and of the Council
15 July 2002
(Available on the EASA web site www.easa.eu.int/doc/BR1592_2002.pdf)
6. The Air Navigation Order 2000 (as amended)
(Available as CAP393 on the CAA web site;
www.caa.co.uk/docs/33/CAP393.PDF)
7. CAP 658 - Model Aircraft: A Guide to Safe Flying
(Available on the CAA web site www.caa.co.uk/docs/33/CAP658.PDF)
8. CAA Paper "Aircraft Airworthiness Certification Standards for Civil UAVs"
D.R.Haddon/C.J.Whittaker
August 2002
(Available on the CAA web site www.caa.co.uk/docs/393/srg_acp_000_16-01-120203.pdf)

Appendix 1

EXAMPLES OF THE UAV CHARACTERISTICS IMPLIED BY THE ENERGY CRITERIA

Proposed criteria

The proposed criteria limiting the eligibility to be exempted from airworthiness certification are:

- o The maximum level speed the UAV can sustain must not exceed 70kts.
- o The maximum operating mass shall not exceed 150kg; (EASA Annex II).
- o At the maximum operating mass the kinetic energies resulting from velocities equal to 1.4 x maximum level speed and the calculated impact velocity for a free-fall from 400ft above the surface, must not exceed 95KJ.

The relationship between mass and maximum level speed

The following table shows the maximum permissible mass and speed combinations if the kinetic energy at 1.4 x Vmax is not to exceed 95 KJ. (Figures are approximate).

Mass of UAV Kg	Maximum speed in level flight (Vmax) Kts	1.4 Vmax m/s	Kinetic Energy at 1.4 Vmax KJ
60	70	50	76
70	70	50	89
75	70	50	95
80	68	49	95
90	64	46	95
100	60	44	95
110	58	42	95
120	55	40	95
130	53	38	95
140	51	37	95
150	49	36	95

The relationship between mass and aerodynamic drag

The impact velocity arising from the “free-fall” scenario will depend upon the

aerodynamic drag characteristics of the falling object and so will be specific to the particular design of UAV. However, for illustrative purposes the table below shows the relationship between the mass and cross-sectional area of a bluff-body, (with a non-dimensional drag coefficient of about 0.9), arising from the proposed 95 KJ limit.

Mass of body Kg	Cross-sectional area of bluff body Square Metres	Kinetic Energy at impact Kilo Joules
80	0 (Negligible drag)	95
115	0.5	95
130	1.0	95
150	1.5	95

Interpretation

UAVs up to 80 kg -

From the data presented above it can be seen that any UAV with a mass of less than 80kg will meet the “free-fall” criterion whatever its drag characteristics and so it need only be considered against the maximum level speed criterion. If the mass is 80kg the maximum achievable level speed must not exceed 68kts. If the mass is less than 75kg the maximum achievable level speed must not exceed 70kts.

UAVs above 80 kg -

The data presented for the “free-fall” scenario shows that if the proposed UAV has a mass in excess of 80kg the constructor will have to provide a justification that the drag of the airframe, falling from a height above the surface of 400ft, will be sufficient to prevent the impact energy exceeding 95KJ.

The potential application of the “free fall” criterion is perhaps best illustrated by considering the example of an airship UAV with a total mass of 150kg.

A 150kg unmanned airship will be eligible for exemption if it can be shown that:

- the maximum sustainable level speed of the airship is less than 49kts,
 - any significant masses (with negligible drag) that might fall from it in the event of structural failure do not exceed 80kg, and
 - the drag of the ruptured/deflated envelope is sufficient to limit the descent velocity of the complete airship falling from 400ft, to the same extent as a bluff body of 1.5m² reference area.
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EXAMPLE EXEMPTION TEXT - PRELIMINARY DRAFT ONLY

1. The Civil Aviation Authority, in exercise of its powers under Article 127 of the Air Navigation Order 2000, as amended, hereby exempts the operator of the Unmanned Aerial Vehicle (UAV) of the following description

for the time being operated by Mr ***** for the purposes of *****, from the provisions of the said Order with the exception of Articles 58, 63, 64, 82, 85, 113, 114, 115, 116, 118, 128 and 129 thereof.

2. This Exemption is granted subject to the following conditions, namely, that the said UAV shall not be flown:
 - (a) for the performance of aerobatic manoeuvres when the purpose of the flight is Aerial Work;
 - (b) at any public flying display except with the prior permission in writing of the CAA;
 - (c) at a height exceeding 400 ft above the surface;
 - (d) at a distance beyond 500 metres from the operator(s) of the said aircraft;
 - (e) within 150 metres of any congested area of a city, town or settlement;
 - (f) within 50 metres of any person, vehicle or structure not under the control of the UAV pilot except that during the take-off or landing a UAV to which this subparagraph applies shall not fly within 30 metres of any person other than the person in charge of the said UAV;
 - (g) for the purpose of aerial inspection of any object or installation that would present a risk to safety in the event of damage due to any impact of the said UAV, nor within (TBD) metres of such an object or installation;
 - (h) unless it is equipped with a mechanism that will cause the said UAV to land in the event of a failure of any of its control systems, including the radio link, and the person in charge of the said UAV has satisfied himself that such mechanism is in working order before the UAV commences its flight;
 - (i) unless the person in charge of the said UAV has reasonably satisfied himself that any load carried by the UAV is properly secured, that the said UAV is in an airworthy condition and that the flight can safely be made taking into account the wind and other significant weather conditions;
 - (j) in Class A, C, D or E airspace unless the permission of the appropriate air traffic control unit has been obtained;
 - (k) within an aerodrome traffic zone during the notified hours of watch of the air traffic unit (if any) at that aerodrome unless the permission of any such air traffic control unit has been obtained.
3. This Exemption shall have effect during daylight hours from ***** until and including ***** for *** purposes only, unless previously varied, suspended or revoked.
