Notes on

KITE AERIAL PHOTOGRAPHY

BILL BLAKE
HERITAGE
DOCUMENTATION

INTRODUCTION

This guide is prepared as an introduction to the acquisition of photography using a kite to raise the camera. It is in 3 parts:

Application
Equipment
Procedure

It is prepared with the help and guidance from the world wide KAP community who have been generous with their expertise and support.

Blending a love of landscape and joy in the flight of a kite, KAP reveals rich detail and captures the human scale missed by other (higher) aerial platforms. It requires patience, ingenuity and determination in equal measure but above all a desire to capture the unique viewpoint achieved by the intersection of wind, light and time. Every flight has the potential to surprise us with views of a familiar world seen anew.

Mostly this is something that is done for the love of kite flying: camera positioning is difficult and flight conditions are unpredictable. If predictable aerial imagery is required and kite flying is not your thing then other UAV methods are recommended: if you are not happy flying a kite this is not for you. If you have not flown a kite then give it a go without a camera and see how you feel about it: kite flying at its best is a curious mix of exhilaration, spiritual empathy with the environment and relaxation of mind and body brought about by concentration of the mind on a single object in the landscape.

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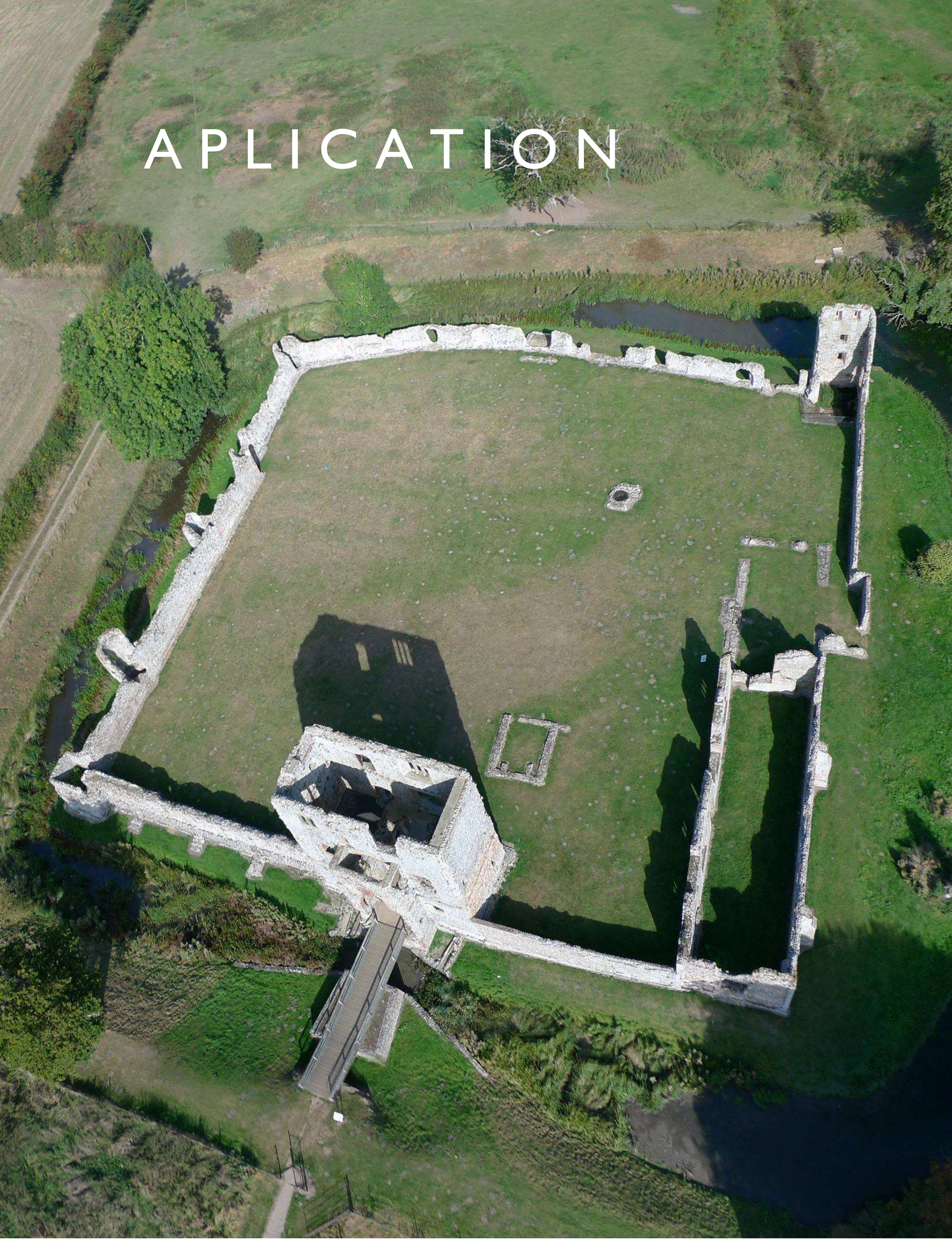
Thanks to Steve Cole for comment on the photographic aspects of the text.

Bill Blake
http://www.bill-blake.co.uk

Acronyms and abbreviations used in this guide:

AGL	Above Ground Level	Absolute datum is rarely used for the height of kites (or aircraft).
AuRiCo	Automatic Rig Control	System of programmable stepped movements of the rig in 2 axes for near 360 sweeps of the camera.
AutoKAP	Automatic Kite Aerial Photography	Light weight passive system of controlling the camera.
Bft.	Beaufort wind scale number	Useful to describe the range of wind speeds experienced.
CAA	Civil Aviation Authority	To whom we must apply to fly higher than 60m
CCD	Charged Coupled Device	The light sensor which records the image in a digital camera.
CHDK	Canon 'Hack' Development Kit	Enables a script to be used to programme the shutter interval on Canon cameras.
Deg.	Degrees	
DSLR	Digital Single Lens Reflex camera	The standard to which camera resolution is compared for KAP. I expect someone has flown a medium format camera but I can't see it becoming common practice.
EXIF	Exchangeable Image File Format	Metadata tags (describing exposure settings, camera identity date and time) embedded in a digital image file.
Ff30	Flowform kite of 30 foot square sail area	Steve Suttons patented kite is often referred to as the ff30, ff16 or ff8 depending on size.
FPV	First person view	A radio linked video camera used to relay the view form a remotely controlled aircraft, a virtual' pilots eye' view.
ISO/ASA		Film sensitivity measure used to describe CCD sensitivity level.
KAP	Kite Aerial Photography	
NATS	National Air Traffic Service	
NOTAM	Notice to Airmen	If you intend to fly above 200' (60m) and permission is granted the CAA will post a NOTAM for a fixed period.
PAP	Pole Aerial Photography	A KAP rig is eminently suitable for using on the end of a pole.
PBL	Planetary Boundary Layer	The layer of the atmosphere we live in.
RC	Radio Control	Often used to mean remote control too.
Rx	Receiver	Radio amateur short hand
Tx	Transmitter	
UAV/UAS	Unmanned Aerial Vehicle/System	Remote controlled aircraft, autonomous mini-copter, dirigible balloon etc.

APLICATION



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History: a brief overview*

In May 1888 Arthur Batut (1846-1918) took the first of 2 photos which in August of that year he sent to Gaston Tissander and demonstrated that he had solved the 2 problems of balancing the weight of a camera with the lift from a kite and remote control of it by taking aerial photographs of Labruguiere, Tarn, France. In so doing he took the first known kite aerial photographs and for this and his subsequent development of the technique he is known as the father of kite aerial photography.

He built a lightweight camera using a 9x12 cm glass plate negative. The camera was attached to the wooden frame of a diamond-shaped kite (which he had bowed for stability) and was triggered by a burning fuse.

The bridge over the river at Labruguiere, Tarn, France taken in March 1889 from a kite by Arthur Batut. His kite line is clearly visible at the bottom left.

By 1890, Batut had published the first book on kite aerial photography entitled *La photographie arienne par cerf-volant*--Aerial photography by kite. In the same year Batut was joined in the enterprise by Emile Wenz, and they developed a close working relationship that lasted many years. They quickly gave up the technique of attaching the camera directly to the kite frame in favour of suspension from the bridle below the kite. In this way, the camera could be brought down and reset while the kite remained flying. (This is very close to usual modern practice where the camera is suspended from the flying line rather than the kite itself).

The 19th century quest for the 'conquest of the air', beginning with George Caley in 1804 and with key advances (among many) by Otto Lilienthal (man lifter1889) and Lawrence Hargrave (box kite 1893), pushed kite technology to ever greater efficiency making kite borne cameras a practicality. The activities of Batut and Wenz in France gained worldwide press attention, and in 1895 kite aerial photographs were taken in the United States by William A. Eddy and Gilbert Totten Woglom.

View from a kite-sustained camera suspended above American Tract Society Building. New York, by William A. Eddy c1895

Image from http://robroy.dyndns.info/KAP-history/photo_miniature/aerial_photography.html

In Britain the development of flight saw kites kept in the public eye by personalities like Capt. B F S Baden Powell, who took successful kite photographs and S F Cody, both demonstrating man-lifting by kite.

By1906 the kite became the aerial platform of choice for George R. Lawrence who lofted a huge 0.6x1.2m panoramic camera of his own design 600m by a train of 17 kites to record San Francisco after the earthquake and fire of 1905 with tremendous resolution that is rarely surpassed even today.

The field was rich with innovative apparatus and experimental techniques. The burning fuse was replaced by mechanical or electrical triggers. Improved cameras, multiple-camera rigs, and ingenious suspension systems were tested and patented. In 1912, Pierre L. Picavet (pronounced 'pickavay'), invented a cable-and-pulley system for suspending the camera below the kite line.

Batut's first images from a simple diamond kite began the development of a practice which continues to this day, new synthetic materials, radio control and digital photography make image capture from a kite ever more practical. In placing a camera in the air by means of a kite we take a step along the journey of discovery began by Arthur Batut!

**Text adapted from 'KAP History' by James S. Aber with additional research by Christian Becot.*

http://www.geospectra.net/kite/history/history.htm *and* http://becot.info/aerophoto/anglais/&specialities.htm

George R. Lawrence's Kite Aerial Panorama of San Francisco 1906.
Reduced version used under Wikimedia Commons permission

KAP Applications
Kites are light, portable, and easy to launch, and their only power requirement is a steady wind. They can soar at altitudes too high or in winds too strong for tethered balloons, and they can be flown at levels so low that aircraft would be impracticable or unsafe. They also can be sent up quickly with little support equipment, so they can be used almost anywhere: from desert basins to Antarctic ice, from Peruvian rain forests to U.S. corn fields.
http://findarticles.com/p/articles/mi_m1200/is_12_158/ai_65952674/?tag=rel.res1

The flight endurance of a kite can exceed many powered UAVs by hours and thus generate a great deal of imagery. KAP is a means of providing low altitude photography, this means typically 30-60m above ground level (AGL) and, with appropriate permissions, (Appendix 1) 120-200m can be achieved comfortably.

Kite flying needs an open space in which to launch and fly the kite. The nature of the kite is such that the *zone of operation* is a critical constraint on its use as a platform for photography: there are many places which are simply not accessible to KAP. Although skilled flyers can make the best of what wind and space they find choosing KAP as a method for a given subject is a choice best left to the kite flyer and it must be accepted other means may be needed to raise the camera in some cases.

KAP can be used for:

- Low level visitor orientation shots of monuments and sites
- Condition recording, particularly of roofs, wall caps and vegetation coverings
- Feature highlighting e.g earthworks and crop marks
- Pattern imagery, particularly of human scale details
- Habitat recording
- Panoramic photography
- Archaeological recording of excavations and post excavation condition recording
- Characterisation studies
- Planning assessment general views
- Producing interesting images from an unusual viewpoint

The principal constraints on conducting photography from a kite are the required height of the image and the wind direction needed to get the best coverage. There are many cases where kite flying is simply not possible:

- Under or near electricity transmission wires
- In urban areas without open space for a launch site or space for a downwind line zone
- Where access to open land is not granted
- On or near highways, electrified railways and the transition zone of operational airfields
- On days without wind (less than Beaufort 2)
- On days with stormy weather (greater than Beaufort 6)

With careful planning and preparation KAP can provide useful imagery of a wide variety of sites, often capturing key images from a unique viewpoint.

Resource Availability
KAP requires 3 key skills:

- Kite flying experience with a load lifting kite
- Technical control systems knowledge
- Photographic knowledge

It also requires specialist equipment maintained in good working order. Although basic KAP operations using 'off the shelf' kit are possible, getting predictable coverage via a remote view system requires maintaining integration of 2 radio systems on a minimum weight budget as well as competence with the flight of kites in a range of wind-speeds. KAP operators with flight experience of a range of kites should be competent to deliver imagery based on a sound assessment of flying conditions and make the right choice of equipment to match the flying opportunity. Kite flying conditions can be very local and KAP fliers need to be familiar with site conditions. The best results come from repeated efforts building on an understanding of local conditions. KAP works best with unobstructed ground upwind of the subject as kite flying in constricted, built-up areas is difficult!

Grimes Graves Neolithic flint mine, Norfolk.

Low level oblique image showing human and animal trackways.

KAP for fun is very rewarding; it is the progression from simply getting a shot from the sky to getting directed photography that marks out serious KAP capability. Site evaluation, weather monitoring and preparedness for flight repetition are characteristics of a flier with a photographic agenda!

As a skill KAP requires an interdependency of equipment and knowledge, a kite is not like other photographic mounts such as a tripod or mast; it demands judgement on when to use it and practice in handling it in a variety of conditions before the operator can be confident about outcomes.

PHOTO COVER

The 'cone' of capture:
A kite will place the camera downwind of the flier, this is obvious but it is the most important factor in planning photocover by KAP, the objective is to place the camera over the subject. It is possible to use height and shoot into the wind but there are 2 problems with this, first there will be a high percentage of shots with the flying line in view and second the camera will recede from the subject as it gains height.

The ideal is for the Sun to be at right angles to wind direction or from behind the flier; shots taken into the sun can be dramatic but often result in poor exposure.

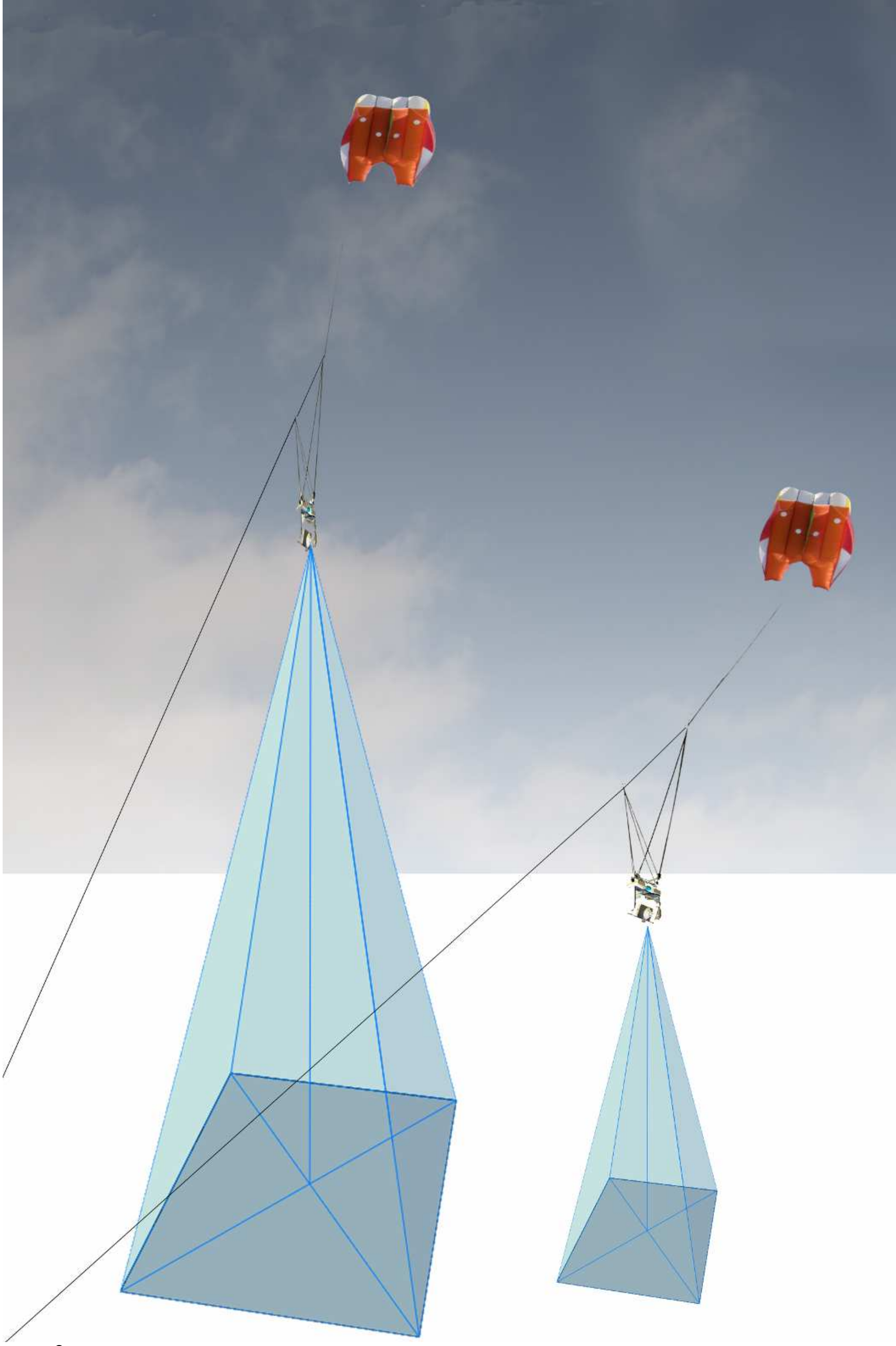
Nadir coverage
Vertical imagery has the poorest coverage; the maximum 60m of available height offers a very small field of view compared to aircraft acquired imagery. KAP vertical coverage is of a very small area, consequently getting a predictable path and overlap is extremely difficult: it can be compared to trying to drop peas in to a thimble from a table top! The difficulty of maintaining a consistent photo-scale is

almost insurmountable due to the variable flying height. The field of view can be increased by using a wide angle lens however there is a trade off between the increase in field of view and image distortion.

The zone of operation
The near ground space required for the flying line can be considerable. Obstructions in this zone such as trees, power cables, telegraph lines and buildings are a serious hazard for the kite. In a steady wind with a stable kite the zone of operation can be very narrow and the kite line can be threaded around obstructions once it is settled at a good height.

In variable winds the kite may need a broad sweep of sky and the clear zone needed becomes deeper and wider accordingly; the kite flier can become 'pinned' to the only spot where the kite will let him stand and photography will be restricted accordingly!

Moving the camera
The camera is moved around the sky in 2 ways: by walking the anchor point



'Wind stagger' variation in cone of capture.

As the wind-speed rises, so does the kite. This increases the field of view and reduces the down wind distance from the flier.

Sequential imagery taken from the rising and falling kite will be subject to big shifts in scale and perspective centre.

(the flier walks the kite) and the natural variation in airflow shifting the kite. Aiming the camera is achieved by remote control of pan, tilt and shutter; a video preview down link improves the process but many fliers work by judgement alone. If the nadir point is known (by an assistant observer) the camera can be moved by walking the kite to the appropriate point and then tracking to left or right, the natural tendency is to move downwind. Walking the kite upwind will temporarily raise it and it should be allowed to settle before shooting.

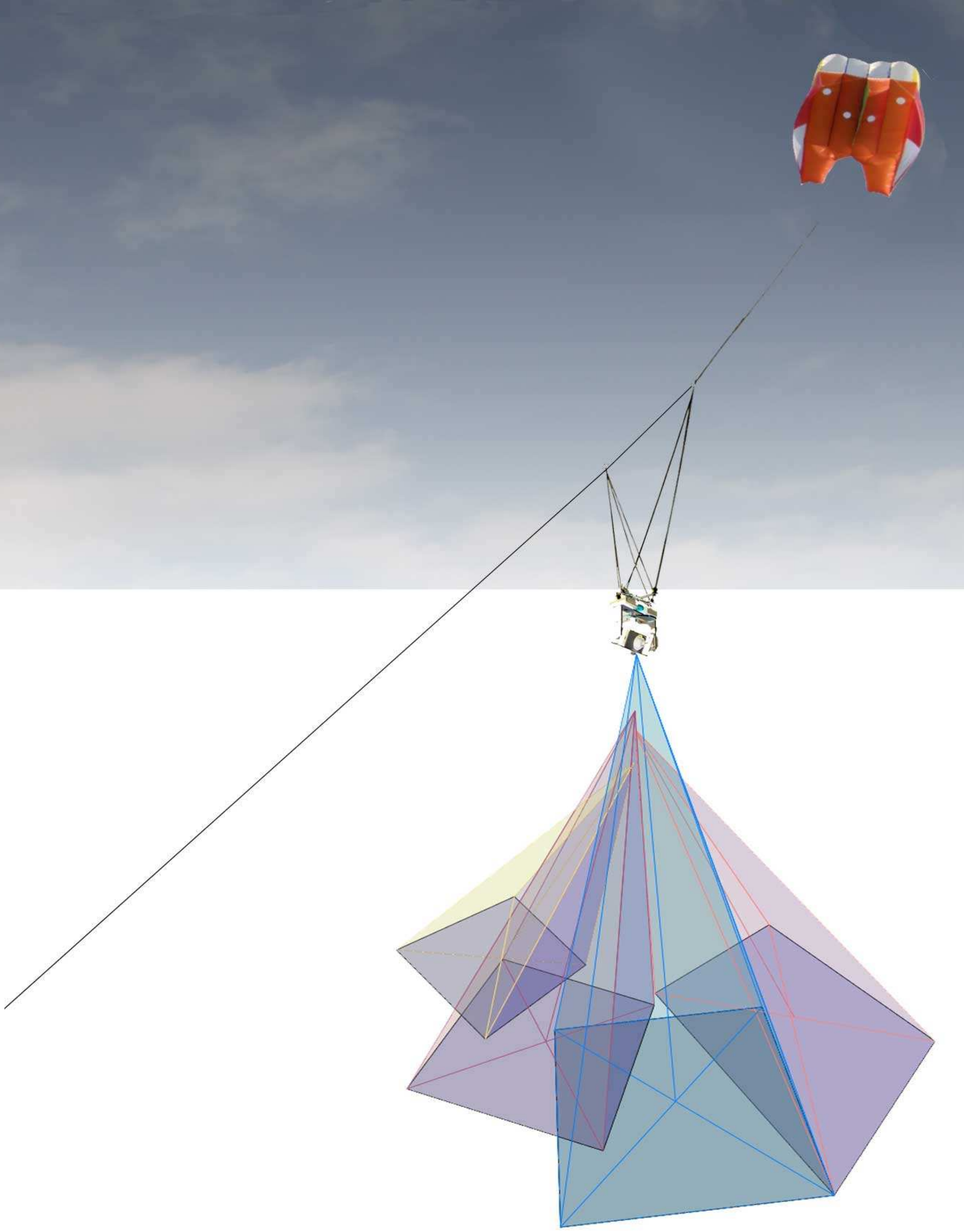
Shooting into the light can be dramatic but shadow areas will lose detail. Camera at 55m AGL

Wind 'stagger'

The kite (and the camera) will rise and fall according to wind speed, it will also increase its distance from the flier as the speed drops, this means that classic parallel swath capture is not easily achievable from a kite, particularly if the flying height is restricted to 60m. The shift between one shot and the next can be beneficial as it can produce a good offset for stereo but it is problematic in getting consistency of swath cover.

Camera direction and Sun position

Pointing the camera at the Sun will generally produce poor imagery. On occasion it is possible to capture great shadow effects when the Sun is low in the sky by shooting against the light but ideally the sun is best placed at right angles to the direction of shot or behind the camera. A predictable direction of illumination is for the Sun to be behind the flier or to fly with the 'wind out of the Sun'



AutoKAP image swath.

The 30 deg pan step generates a series of fan arrayed shots. The consistency of the coverage is dependant on the stability of the airflow; this diagram shows the effect of typical shifts in height superimposed on a single centre of rotation. In practice the centre will shift in plan between shots also.

*The imagery is of variable scale with multiple perspective centres and consequently very difficult to mosaic! Using a **fixed nadir rig** with an intervalometer will improve the image condition for photo-mapping.*

AutoKAP

Fixed nadir rig

The simplest form of AutoKAP is to capture imagery on a fixed camera orientation and achieve coverage by walking the camera across the area to be mapped, the flier will need to anticipate the offset between the kite and the camera and estimate the coverage achieved relative to the rate of movement. A very simple rig can be used for this and the results can be most effective. Photomaps based on simple nadir rigs can be achieved either as un-scaled mosaics or as metric 'otrhophotos' if sufficient control is available. Marking control points in sufficient density for KAP coverage is a considerable undertaking and derived control from existing mapping should be considered as an alternative to pre-marking the site.

Automated Pan and tilt stepping

AutoKAP is a method of moving the camera in fixed steps by robotic control, there are 2 variants: Pan only and pan and tilt, an intervalometer is used to take shots at a fixed time interval, say every 5s. The basic set up steps the pan axis in 30 deg steps. The advantage of the technique is that the flier can capture imagery without taking any action to control the camera, thus making the operation relatively easy for one person to operate. Capture simply requires the kite to be kept 'on the spot' for the time it takes for a 360 sweep and them moved on to a new centre.

Oblique fans
Basic pan step AutoKAP generates oblique fan imagery which has a consistent lack of parallelism. Registration of multi perspective centres is difficult as each image has a rotation of perspective centre relative to the next.

NOTE ON CAMERA SETTINGS

It's all too easy to rely on 'Auto' and for many cameras this will probably work well most of the time. Things start to go awry in low light, the Auto setting will generally assume a longer shutter speed is needed and the effect will be to increase the number of shots wrecked by motion blur. It is tempting to up the shutter speed but this will have the effect of under exposing in low light.

"When I'm launching close to sunset, I usually try to set the camera in aperture priority mode with exposure compensation to -2/3 (to avoid blown highlights under contrasty conditions), and the ISO as high as I find acceptable. I feel that setting the aperture fairly wide open and allowing the shutter speed to vary is much better than setting a fixed shutter speed and severely underexposing many images. I have learned the hard way when setting the shutter speed at 1/500th or 1/1000th at the start of a KAP session with diminishing light.

With my dSLR, I'll usually set the camera to f/3.5 (the largest aperture on my kit lens) or f/4 with an ISO of 400. If I think I'll continue flying after the sun sets, I'll often set the ISO to 800.

On my Canon S90, I try not to go above ISO 100, despite its larger sensor and reportedly better performance at higher ISOs. I'm so used to the dSLR's image quality at higher ISOs that even at ISO 200, I don't like what I see with respect to noise from the S90. Printed images may not look as bad as on my monitor, I really should try a print test.

Even though my EXIF data shows manual exposure on the UC Berkeley sunset image (right) I was in aperture priority mode at f/2.5 (largest aperture on this camera is f/2, but I figure stopping down a little might keep things sharper on the edges and in the corners), with ISO 80. At 10 minutes before sunset the camera chose a shutter speed of 1/200th under these conditions. It definitely would be nice to feel good about ISO 200 (or 400) with the S90, which would have decreased the shutter speed more than 2 (or 4) fold, so I really will have to do some print tests."

Michael Layefsky
August 2010

Low level oblique image recording hidden cill and lead capping condition.

Low level oblique image recording wall cap condition.

Photomap montage of 9 images selected from 1,296 acquired over a 2.5 hours continuous capture flight. Nadir Imagery collected from 35 to 60m AGL. Overcast lighting has eliminated shadow allowing near continuous surface coverage. Vegetation condition and visitor erosion tracks are clearly visible. Some evidence of the earlier course of the River Stiffkey is revealed.

Radio Astronomy Installation at Haslingfield, Cambridgeshire

Details of One Mile Array reflector from 40m AGL

EQUIPMENT

The essentials are
C A M E R A
R I G and its suspension and controls
K I T E flying line and harness

C A M E R A

Aerial photography traditionally uses very highest quality cameras and KAP is no exception in its demands on image resolution.

To choose a camera to fly there are two considerations: image quality and weight. KAP works best in the lightest winds possible, strong winds are turbulent and place every part of the system under stress, including the flier! Light winds have their own problems but things will happen gently and the stability of the camera will be greater despite the frustrations of slow launches and poor flying angle. So the camera needs to be lightweight with the best resolution possible, by placing the camera in the air, details you are familiar with on the ground will appear much smaller than you expect and push the resolving power of the lens to the limit.

Henry Welcomes KAP rig and traveller at the excavation of Jabel Moy ,Sudan in 1913
photo copyright Welcome Foundation

Power: You will not be able to turn the camera off whilst it is in the air, so setting up your camera to save the maximum amount of power is desirable and carrying spare batteries is a must.

Format: a compact camera will be lightest but will lack the image capturing performance (or *resolution*) of a DSLR due to its smaller sensor and the optical qualities of its lens. The DSLR might offer better optics, more instantaneous image capture and a larger sensor but will add considerable weight to the rig and will restrict the number flying days achievable as the higher wind speeds needed to lift it tend to be turbulent and increase the risk of damage during 'heavy landings' accordingly. The ‘micro four thirds’ format offers some of the benefits of the DSLR (large CCD, interchangeable lenses etc) and some of the compact (light weight, small size) formats and so it is well suited to KAP.

Desirable features for a KAP camera in addition to good resolution and light weight are:

- standard ‘hot shoe’ for fitting a shutter servo
- video relay of the preview screen
- thread for a polarising filter or lens adaptor
- tripod fixing thread for mounting the camera securely to the rig

Lens:
Focal length: Common usage in describing lenses refers to focal length of the 35mm film format ‘prime’ sizes:

- 50mm ‘Normal or ‘Standard’ lens with: angle of view of about 50° considered to have similar magnification and field of view properties to the human eye
- 28mmm or less ‘Wide-angle’ lens with an angle of view wider than 60°
- 100mm or more ‘Telephoto’ lens or long-focus lens, a much reduced field of view:

‘Zoom’ lenses are constructed to have the properties of an adjustable focal length from ‘wide’ to ‘telephoto’ (sometimes called ‘tele/wide’) they have advantages in flexibility but disadvantages in aperture, light loss and weight. For KAP wide angle lenses seem appropriate because, at the expense of some aberration around the edge of the image, it’s easy to frame the subject in the wider field of view.

A selection of commonly used 'pro compact' cameras used for KAP, in descending order of weight per sensor area:

Camera	Weight	Key feature	Sensor size	Sensor area/ weight. mm² per g
Canon G11	335g	10mp programmable	7.60 x 5.70 mm	0.12
Ricoh 'Calipo' GX200	238g	12mp	7.60 x 5.70 mm	0.18
Panasonic Lumix DMC-LX3/ LeicaDlux4	228g	Leica Wide Angle lens. Image stabilisation	8.17 x 6.13 mm	0.21
HD GoPro 3	76g	14mp 'super wide' video camera	5.76 x 4.29mm	0.325
Panasonic DMC GF1	485g*	Interchangeable lenses. Micro 4/3rds format. 'On lens' stabilization	18 x 13.5mm	0.5
Olympus EP1	406g*	Interchangeable lenses. Micro 4/3rds format. 'On board' image stabilisation. 2/3rds full frame CCD.	18 x 13.5mm	0.598
Olympus E-PL1	368g*		18 x 13.5mm	0.66
Fuji X-E1	430g	16 mp 'X-Trans' CMOS Sensor. 14mm wide angle c.80g	23.6 x15.6mm	0.85
Ricoh GXR 'S10' or 'P10'	397g	12Mp. with 50mm 'A12' lens Interchangeable lens/sensor packs available.	23.6 x 15.7mm	0.903
Samsung NX200	305g*	21Mp, Samsung EX-S30NB 30mm f/2.0 Pancake Lens =85g	23.5 x 15.7mm	1.002
Sigma DP1/DP2	278g	14mp	20.7 x 13.8 mm	1.027
Leica M9	825g	Full frame, 585g body. (+240g for 50mm Summicron f/2 lens)	36 x 24 mm	1.047
Leica X2	345g	16Mp Fixed 35mm equivalent focal length lens.	23.6x 15.8mm	1.08
Sony Nex 5	317g*	Interchangeable lenses. Sony 'E' mount. 14mp	23.4 x 15.6 mm	1.12
Leica X1	286g	12mp. Fixed 35mm equivalent focal length lens.	23.5 x 15.7 mm	1.29

**includes lightweight wide angle 'pancake' lens*
Table updated 4.11.2012

Micro 4/3rds format
Compact cameras with a sensor of 18 x 13.5mm (or 4/3rds of an inch diagonal, 'micro 4/3rds' refers to the miniature lens mount standard adopted for compact cameras using the 4/3rds sensor) are light, have a good sized sensor and selectable lenses. The lighter models are ideal for KAP.

Full Frame format
Full frame format refers to equivalence to the 35mm film frame size. Full frame sensors are bigger than those used in most 'compact' cameras. The large sensor size produces better image quality but usually at the cost of using a heavy DSLR camera. The Leica M9 is exceptionally light for a full frame camera as its 'range-finder' design saves the weight of the mirror and prism used in classic SLR designs.

Shutter actuation and memory delay:
Some cameras can take a long time to process the image information from the sensor before the next shot can be taken. This is a particular problem on some compact cameras that use a large sensor array. The Sigma DP1 can take 4s to complete its auto-focus sequence and a further 12s to write the image file off the sensor onto the memory card. This is a problem resulting in poor framing when photographing from a moving platform like a kite. Using such a camera will require patience!

NOTES ON CAMERA PERFORMANCE
The resolution of the camera is a function both the design and component quality (particularly of the optical chain) of the camera and the photographer's choice of exposure settings. There are 3 key factors to consider:

1. Optical resolving power of the lens and the optical path design.
The transmission of focussed light rays to the sensor is the critical thing. This is fixed by the camera and lens design with bigger lenses and bigger internal focussing distances tending to give better resolution. There are good miniature cameras but if you want to print images at exhibition resolution all comparisons begin with the DSLR design. Small compact cameras use very small sensors to record the image which means that the performance of each component in the sensor is optimised for miniaturisation. The pixel count on these small arrays is increasing as the technology develops but the noise associated with these miniature arrays is a problem. The balance between these factors can end up with good image quality at wide apertures and slow shutter speeds or conversely a low pixel count but good exposure response.

2. Sensor performance
Effective performance of the sensor and its associated processor is a function of the density of sensor elements, how close together they are and the sensitivity and overall size of the array, how many sensor elements (often, but not always, pixels) there are, together with the image processing algorithms used all affect the quality of the captured image. Selecting a high sensitivity (high ISO settings) introduces noise into the image and degrades the quality.

3. Exposure
Most lenses have an optimum aperture of about f8 (usually about two stops down from the widest aperture). The shutter speed will be determined more by the need to arrest motion blur more than anything else. Exposure is a compromise between shutter speed, aperture and ISO setting. The brightness of objects on the ground is something of a surprise so care should be taken not to over-expose with too wide a stop as detail in the highlights will be lost. A high shutter speed will reduce motion blur at the cost of forcing wider aperture settings or higher (noisier) ISO settings. An EV (exposure value) setting of -1/3rd helps reduce 'burn out' of white or bright objects in bright light.

Camera settings for best resolution
Sharpness from foreground to background, known as 'depth of field' is a function of the aperture used, the focal length of the lens and the distance between the lens and the subject. As mentioned above noise introduced by high ISO settings will also affect the quality of the image.
A good mix in strong light for most cameras is:

Aperture=f 8
Sensitivity or ISO= 400
Shutter Speed=1/125^{ths}

A polarising filter which deals with reflections and glare is useful as the high viewpoint will capture a great deal of reflected light from unforeseen sources. When the polarising filter is used the aperture will need to be wider by 2 full stops at f 4.8 or 6)

Photo scale (vertical (nadir) case)

$$S = f / H$$

Where S = scale of the photograph, f = focal length of the camera (in metres) and H = height of the camera (in m).

Stability (anti shake) settings
If the camera has anti-shake control this should be used as it *will* be subject to vibration.

COMPARATIVE RESOLOUTION

The top image is taken with the Canon Ixus 70 and below the by the Sigma DP1. The Canon is unmodified at focal length of 17.4mm and the Sigma fitted with a Ricoh DW-6 .79x converter which works out at something like 28mm equivalent. Despite the much smaller CCD size and lower pixel count on the Canon the image is sharper.
The lower quality of the Sigma image is likely to be a product of the optical quality of the adaptor and the algorithms used to process the image after capture.

In looking for a KAP camera it is desirable to have the best mix of weight, lens, focal length and pixel count, however good lighting will improve the performance of any camera!

RIG

The rig has to perform 4 functions:
- Stable support,
- pan,
- tilt and
- fire the camera shutter,

additionally it may be used to transmit an image preview to the ground. For some, the rig is an all consuming passion; there is always a refinement in weight, miniaturisation, material or control to be made! If you build one you are solving some nice engineering problems with a balance between weight and rigidity as constraints. The requirement is to be able to pan, tilt and trigger the camera remotely whilst it is safely suspended from the kite line. Fortunately good rigs can be bought 'off the shelf' made by Brooxes at the excellent KAPShop *www.kapshop.com*. The rig needs to be rigid, lightweight and equipped with radio control with a good range and power life as, unlike other RC users; the kite may fly for hours so the transmitter and receiver need a high capacity power supply.

Rig construction:

Weight vs. rigidity

Ideally the rig should have no more mass than that needed to support the camera and its control devices: it should not be designed to with stand a crash impact as its mass would exceed the available lift of most kites. It is inevitable the rig will take some knocks and have to withstand transport to and from the flying field; a careful balance between strength and weight must be achieved.

Suspension system Picavet vs. Pendulum:

Pendulum is heavy but gives a very stable and predictable camera position, there is very little backlash and stabilisation is very quick if a semi-rigid joint is used.

The Picavet is light but much more mobile in higher wind speeds: ideally one would use a Picavet in light winds and a pendulum in higher, in practice it is not easy to swap over suspension systems so kappers tend to opt for one or the other. A disadvantage of the Picavet is it can be a headache to untangle if it goes wrong-keep the lacing diagram handy and keep a check on the pulley wear on the suspension lines. A big advantage of the Picavet is it packs away nice and small where as a pendulum and bar is a bit bulky.

Radio Control:

Radio control is used for the remote control of pan, tilt and shutter, this is not the only method of achieving camera movements as an automated series of shots can be made using AutoKAP (see AutoKAP at the end of this section).

In the UK and Europe (Region 1) there is a legally binding agreement that the 40 MHz band is reserved for ground based radio controlled models and 35 MHz for airborne. There are several widely used suppliers of standardised components and choosing an RC brand is an important consideration because of the compatibility of connectors, voltages etc. tends to be brand dependant. It is desirable to be able to replace components quickly and easily as a KAP rig will demand more of the servos in terms of shock loading and torque than a model aircraft. RC modellers use systems which have been developed for over 50 years so making use of a model aircraft set comprising matched transmitter, receiver and 3 servos is a good way to begin.

Using a kite mounted receiver and three compatible servos, the pan, tilt and shutter can be controlled by joystick controls on the hand held transmitter.

Image preview:

The main problem with operating the camera remotely is that it is very difficult to tell what the camera is pointing at: even with binoculars. The orientation of the camera is largely unknown unless the camera view can be seen on the ground. To overcome this problem a low powered (10mW is the unlicensed limit for video) video transmitter is installed on the rig so that the image seen by the camera is transmitted to a portable receiver on the ground. There are a number of licence free channels in the 2.4GHz band making it is possible to mount a specialised lightweight TV transmitter on the kite rig and operate it from the same battery used by the control receiver and servos. Voltage conditioning equipment may necessary as often the video camera supply is incompatible with the control receiver supply.

FPV or 'first person view' flying is the new hobby of flying a model airplane through a wireless video camera as the availability of lightweight miniature video cameras has allowed operation of radio control model aircraft by using a ground viewable 'pilots eye' video link. KAP can use much of the same technology but has to overcome the interference problems caused by the proximity of the RC receiver and the video transmitter.

Multiple radio installation:

In a model aircraft the RC receive antenna and video transmit antenna can be easily separated either by the fuselage length or the wingspan. This is not the case with a kite mounted setup. On a kite mounted camera the rig is compact and therefore any transmitting antenna is bound to be physically close to the RC receiving antenna and associated wiring to the servos. The orientation, screening and separation of the antenna for RC control and video link requires careful design to avoid the 'deafening' of the RC receiver by the video transmitter. The effect is to cause the rig controls to become unstable at distance from the RC transmitter so the control signal is 'swamped' by the video transmitter and the receiver sends garbled servo control signals to the servos resulting in uncontrollable 'jitter' of the rig movements.

This swamping is analogous to trying to hold a conversation with someone listening to heavy metal on their iPod! Even though the T.V. transmitter signal is far removed in frequency from the 35 MHz control signals, the receiver does not clearly 'hear' the messages being sent to it resulting in the servos behaving erratically.

There are several mechanisms whereby interference is presented to the receiver and therefore several methods of minimizing the interference problem.

1. Separate the antennae as far as possible to opposite sides of the rig.
2. Mount the antennae mutually at right angles and with opposing polarities for example one vertically and the other horizontally.
3. Use a high specification 'dual conversion' type receiver.
4. Screen the r/c receiver to minimise direct 2.4 GHz radiation into the set.
5. Fit a filter on the antenna input to the r/c receiver to block 2.4 GHz but allow the 35 MHz signal through.
6. Fit Radio Frequency bypass filters to the appropriate signal and/or power lines in the rig.

Ground reception of video link

As the 2.4 GHz transmitter has a 10mW restriction on the output power (See Appendix 3), it is necessary to either use a directional antenna on the receiver, or to obtain a license to use a higher powered transmitter on the camera rig. Several designs of gain antennas can be employed; however a patch antenna on the receiver boosts reception adequately. Although bulkier than a standard omni-directional antenna, a patch antenna is light in weight and can be worn by the kite flier easily in a neck bag, and can co-exist with the receiver.

AutoKAP

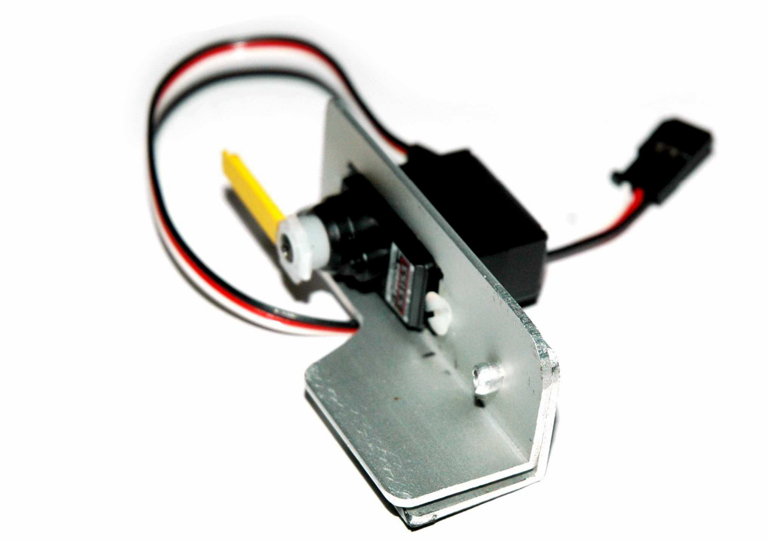
AutoKAP is the term used to describe passive, automated image capture from a kite. It has the key benefits of

- Light weight, low power rig
- High volume of images captured
- Simple operation
- Kite flier relaxation!
- Good base material for panoramic treatments captured.

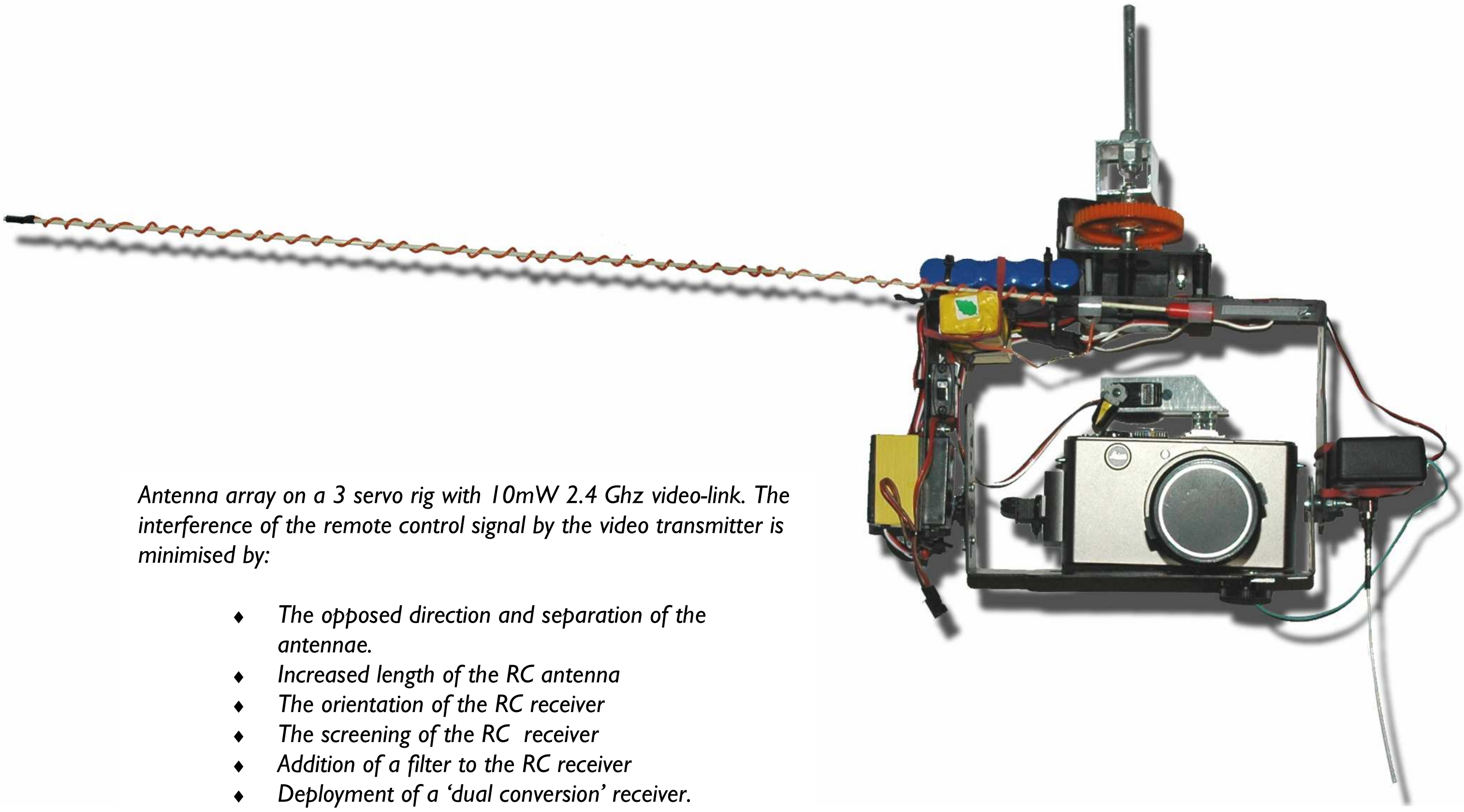
It has the disadvantages of

- Slow speed capture,
- produces a very large number of images to process
- Lack of user control.
- No image preview

AutoKAP can be automated in a number of ways varying from fuses, rubber band, clockwork, step driven servos, firmware scripted (CHDK) intervalometer, to programmable 2 axis systems.



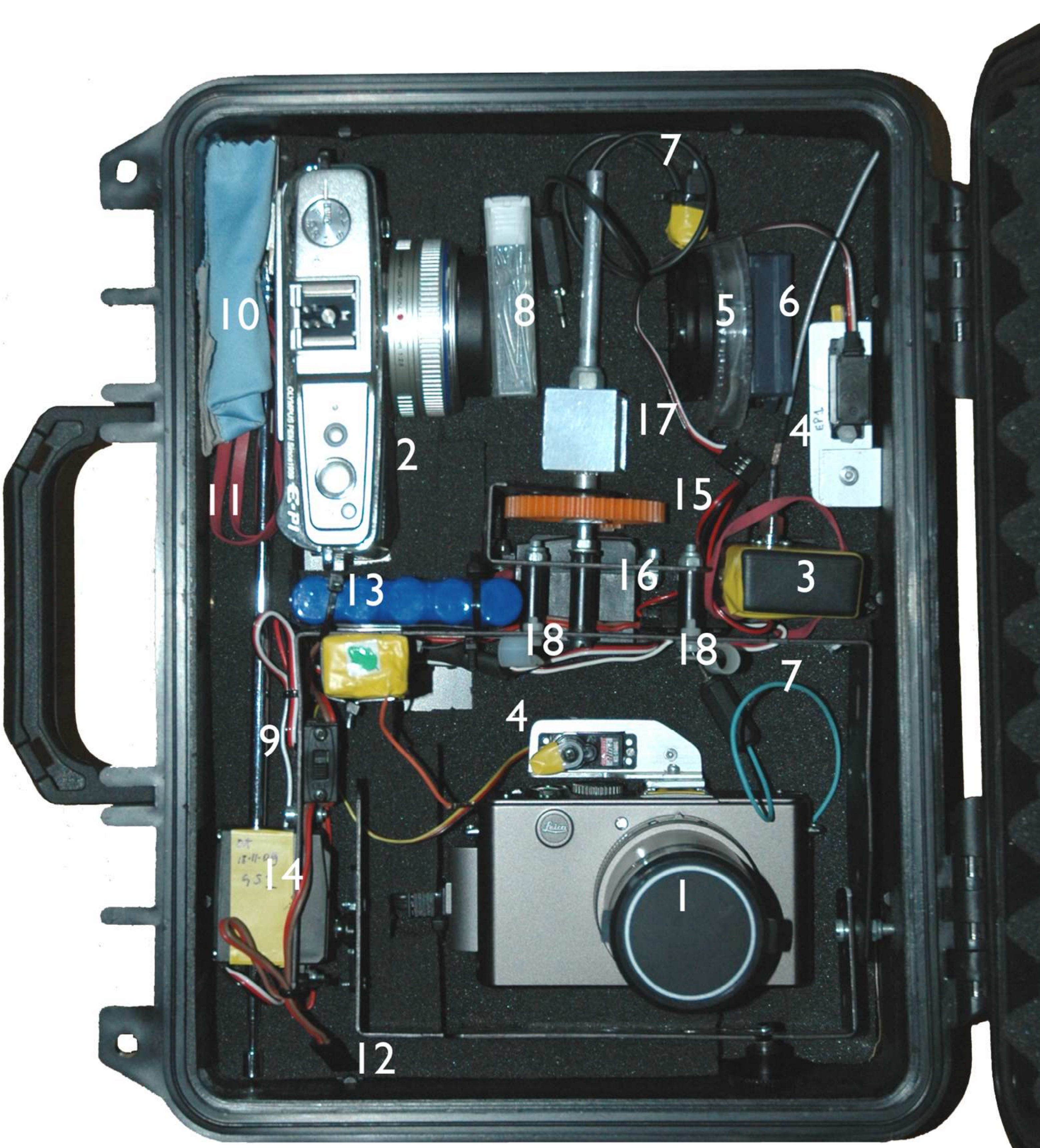
A simple hot shoe shutter servo mount is easily made from 2 pieces of stock aluminium section. The servo is a 'mini' type which gives better clearance for the tilt motion and saves weight over a 'standard' pattern one.



Antenna array on a 3 servo rig with 10mW 2.4 Ghz video-link. The interference of the remote control signal by the video transmitter is minimised by:

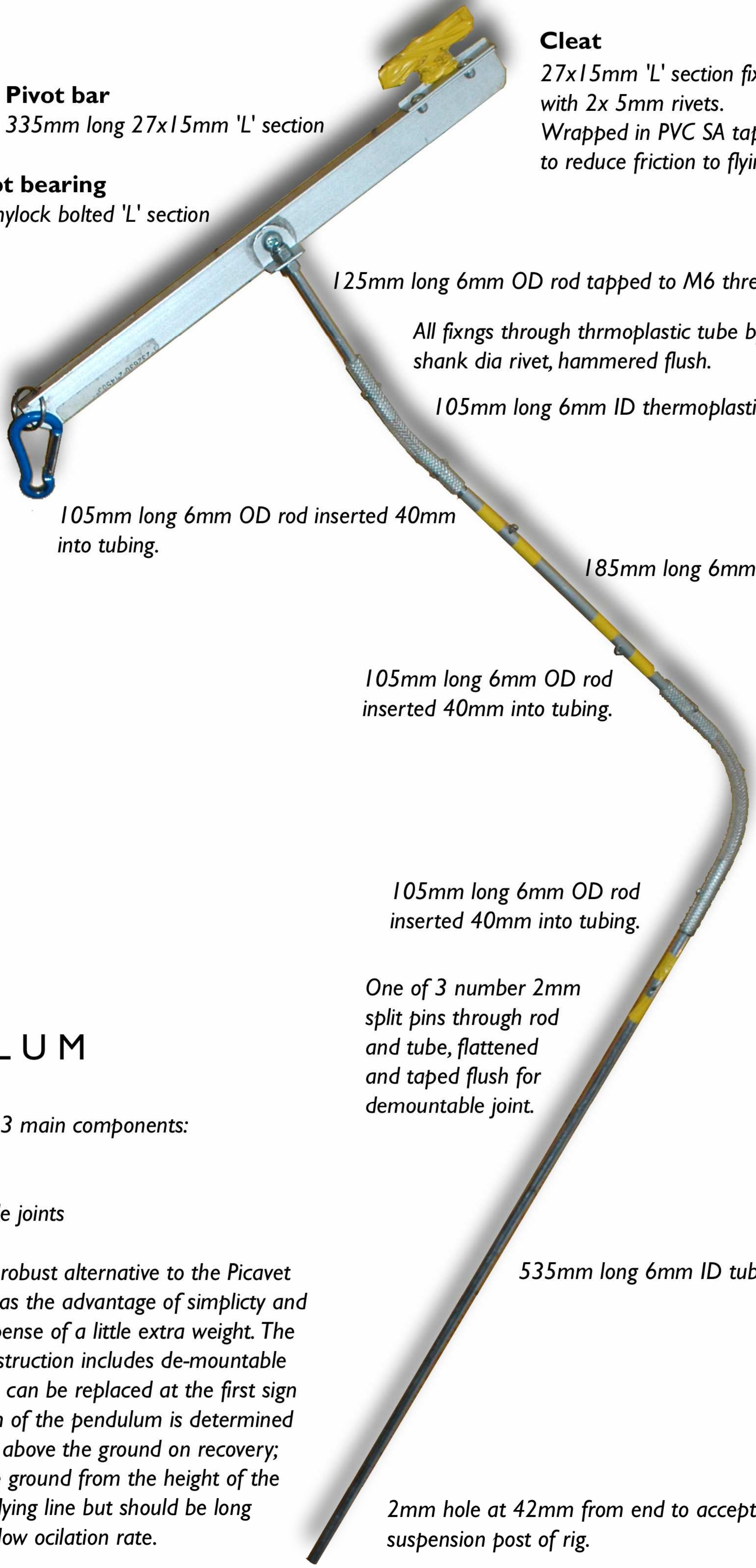
- *The opposed direction and separation of the antennae.*
- *Increased length of the RC antenna*
- *The orientation of the RC receiver*
- *The screening of the RC receiver*
- *Addition of a filter to the RC receiver*
- *Deployment of a 'dual conversion' receiver.*
- *Reduction in efficiency of the video link transmitter antenna*

AutoKAP rigs can be very light and make best use of simple 'point and shoot' compact cameras. An AutoKAP capacity is a useful reserve in light winds as, although the shot selection is near random, it will get some coverage when a radio controlled rig can not be airborne.



RIG FIELD CASE

1 10.2 Mpixel Lightweight camera
2 12.3 Mpixel camera
3 Video transmitter with altimeter relay
4 Shutter servo hot shoe mount x2
5 Polarising filters
6 Camera battery
7 Video link cable x2
8 Split pins
9 RC transmitter aerial (de-mounted)
10 Lens cloths
11 Rubber bands for mounting video Tx and RC aerial
12 Charging tail
13 6v battery
14 Gyro stabilised Tilt servo
15 Pan gear
16 Pan servo
17 Pendulum mounting post
18 RC aerial mounting clips



PENDULUM

The pendulum has 3 main components:
The pivot bar
The pendulum rod
The (2) semi flexible joints

The pendulum is a robust alternative to the Picavet suspension which has the advantage of simplicty and durablity at the expense of a little extra weight. The all alumininum construction includes de-mountable flexible joints which can be replaced at the first sign of wear. The length of the pendulum is determined by the hieght of rig above the ground on recovery; it should not hit the ground from the height of the fliers hand on the flying line but should be long enough to have a slow ocilation rate.

G R O U N D E Q U I P M E N T : Camera Control

1 *Standard model aircraft 3 Channel 35Mhz Radio Control Transmitter. The tilt (up/down) and shutter (push and release to L or R depending on servo) are on the LH stick and the pan on the right. The antenna is demountable for transport and field survival.*

2 *2.4 GHz Receiver, self powered with 8 selectable channels. (Fitted in camera operators neck bag for field use)*

3 *Custom made patch antenna which increases the signal strength from the video relay (Fitted in camera operators neck bag for field use)*

4 *2.5" Colour screen, self powered with clip strap to fix to RC controller. Supplied as a test monitor for CCTV installation.*

K I T E

The Sutton Flowform 30 (30 Sq ft / 2.7 m^2) is a very stable kite and handled with care (appropriately tailed or drogued) it will function in a wide variety of wind speeds. It can be awkward to handle at launch, especially in light winds, but its stability (particularly if the modifications developed by Christian Becot are carried out) is exceptional. The kite needs a minimum of 3.5mph wind-speed to lift a camera and rig of about 700g. One disadvantage of the flowform is that it can only be manoeuvred by moving the point of anchorage; it is not a kite that can be 'steered' in light winds the way delta kites can. The Sutton flowform is a development of the Jalbert parafoil design which has tremendous lift properties by exploiting a very light weight, air filled, aerofoil pattern.

Steve Sutton (b 1946) began his sport parachuting career in 1965 at the age of 19. He was a member of Canada's National Parachute Team from 1970 to 1972. He competed in two World Championships, winning silver medal in men's accuracy in 1972. In the early 1970s, Sutton started modifying his parachutes to improve their flight characteristics and stability. A few years later, he used his aerodynamic concepts to develop a series of kites of different sizes.

As Sutton developed and tested his designs, his goals were to harness the abundance of high-pressure air in a foil-type kite or parachute, and use it to create both thrust and stability. The features he developed (and later patented) included a series of vents in the top and bottom surfaces of the wing, and a large vent in the trailing edge. All flowform kites have very deep profiles. These large cells provide a stronger and more stable structure. Although one would expect this to result in a huge amount of form drag, in fact, drag is greatly reduced *because of the large volume of air that passes through the kite. This explains why the kite is so light on the line, even in heavy winds. As well, the flowform is self-regulating, maintaining constant flight characteristics despite changing wind conditions. This is because the kite adapts to different amounts of air flowing through it. Sutton's concepts had never before been used in the field of aerodynamics. The original airfoil-type parachute design by Domina Jalbert, and later developments by others, were all limited to using the air entering the front of the cells to maintain inflation (hence the name "ram-air"). Sutton's concepts were new in that they allowed differing air pressures to flow through the structure in a thrusting and stabilizing fashion. The result was a kite with excellent flight characteristics.*

In 1984, Sutton granted a license to Air Affairs Inc. of Hatboro, Pennsylvania as the exclusive manufacturer and distributor of the flowform.

Thomas-Michael Rudolph 1998

http://www.fang-den-wind.de/ff_devel_eng.htm

Parafoil and paraform

Domina Jalbert (1904-1991) was born in St-Michel-des-Saints (Quebec). Still in his youth, his family moved to Woonsocket (Rhode Island) where he received American citizenship. An early aviation pioneer, Jalbert obtained in 1927 private pilot license no. 626. Growing up with a passion for kites, he conceived huge advertisement kites (with the help of his mother at the sewing machine). With war approaching, he was hired by the United States Rubber Co. for the design of barrage balloons that defended London against air attacks. His first major invention, the "kytoon", came from this period. A combination of "kyte" and "balloon", it has since been used for aerial photo, radio antenna deployment, atmospheric research, the lifting of heavy logs, etc.

Jalbert founded in 1949 the Jalbert Aerology Laboratory, soon involved with parachute design. In 1953, flying his Beechcraft airplane, Jalbert had a sudden inspiration: why not build a parachute with the shape of a wing? So came to be the "parafoil", a flexible wing with cells open to the flow of air, generating lift. Granted patent in 1966, the parafoil generated immediate interest and was considered by some as the most radical departure in parachute design since Leonardo de Vinci. The parafoil (nicknamed a "flying mattress") was rapidly adopted by the American parachute team Golden Knights. Also known as ram air parachute or square parachute, the parafoil is however very different from a standard dome chute in the way that, as Jalbert explained: "the parafoil was not invented as a descending device, but as an ascending one".

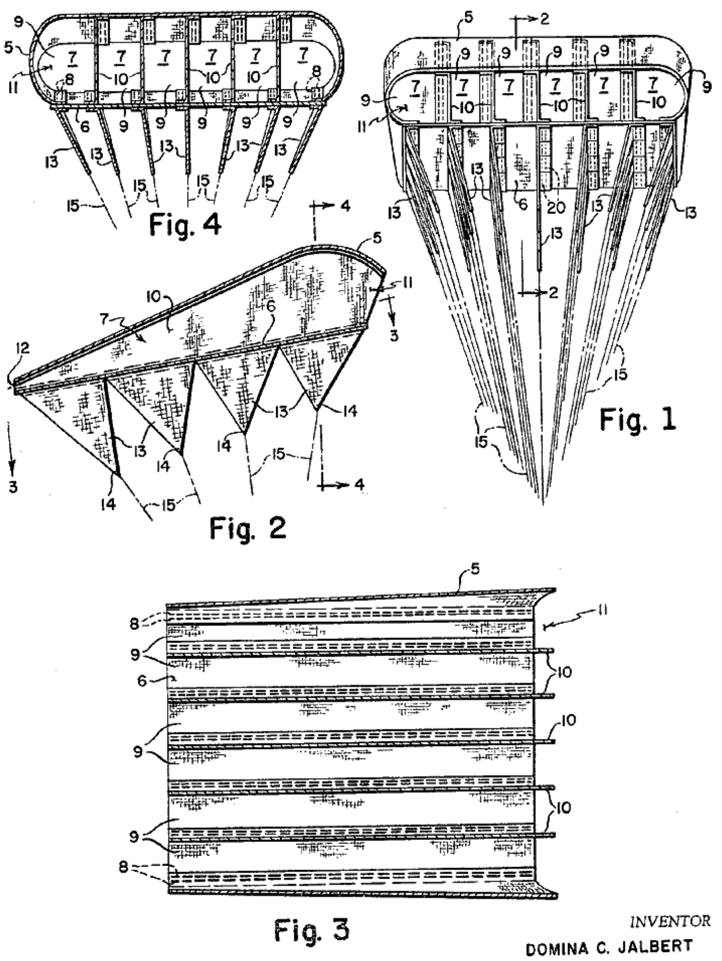
Forerunner of paragliders and traction kites used for paraski and kitesurfing, the parafoil was also tested by NASA for space capsules re-entry. Recently, NASA resumed parafoil testing with the (now cancelled) X-38 CRV prototype. The future crew return vehicle glided back safely to earth suspended under a giant 7,500-square-foot parafoil wing (almost one and a half times the wing span of a Boeing 747 !). One previous world record was held by Jalbert himself who, in 1980, flew a huge 3,640-square-foot parafoil kite. Generating more than 10,000 pounds of lift, the kite was attached to a truck filled with 20 tons of gravel. In 1983, a gigantic 10,000 plus-square-foot parafoil kite was also tested.

http://www.aerovision.org/doku.php?id=en:domina_jalbert

Nov. 15, 1966 D. C. JALBERT **3,285,546**

MULTI-CELL WING TYPE AERIAL DEVICE

Filed Oct. 1, 1964 2 Sheets-Sheet 1



INVENTOR
DOMINA C. JALBERT

BY [signature]
ATTORNEY

United States Patent [19] [11] **3,893,641**

Sutton [45] **July 8, 1975**

[54] **FLOW FORM DEVICE**

[76] Inventor: **Stephen John Sutton,** 16 Edgevalley Dr., Islington, Ontario, Canada

[22] Filed: **Apr. 18, 1974**

[21] Appl. No.: **462,027**

[52] **U.S. Cl.** **244/145;** 244/142
[51] **Int. Cl.** **B64d 17/18**
[58] **Field of Search** 244/16, 142, 145, 152

[56] **References Cited**

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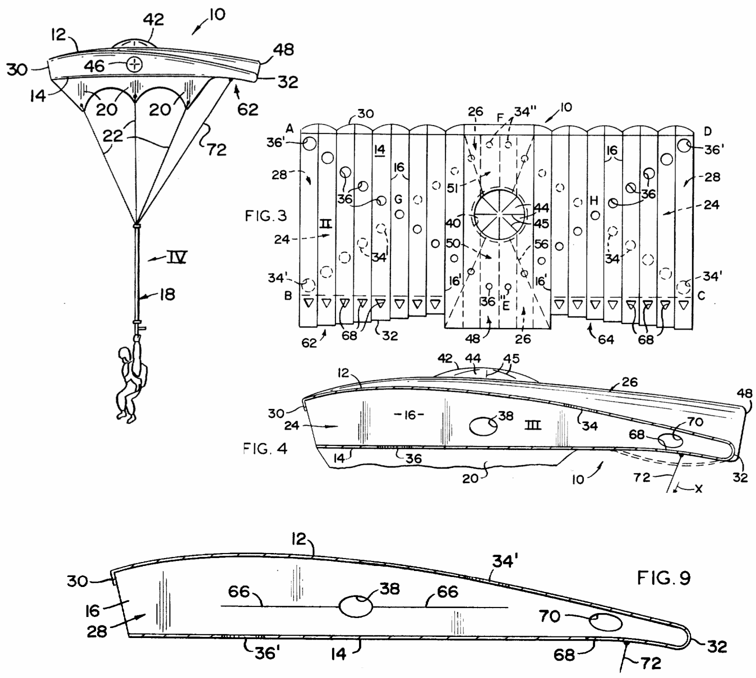
3,749,337	7/1973	Jalbert	244/145
3,822,844	7/1974	Sutton	244/145
R26,427	7/1968	Jalbert	244/142

Primary Examiner—Trygve M. Blix
Assistant Examiner—Paul E. Sauberer
Attorney, Agent, or Firm—Stein & Orman

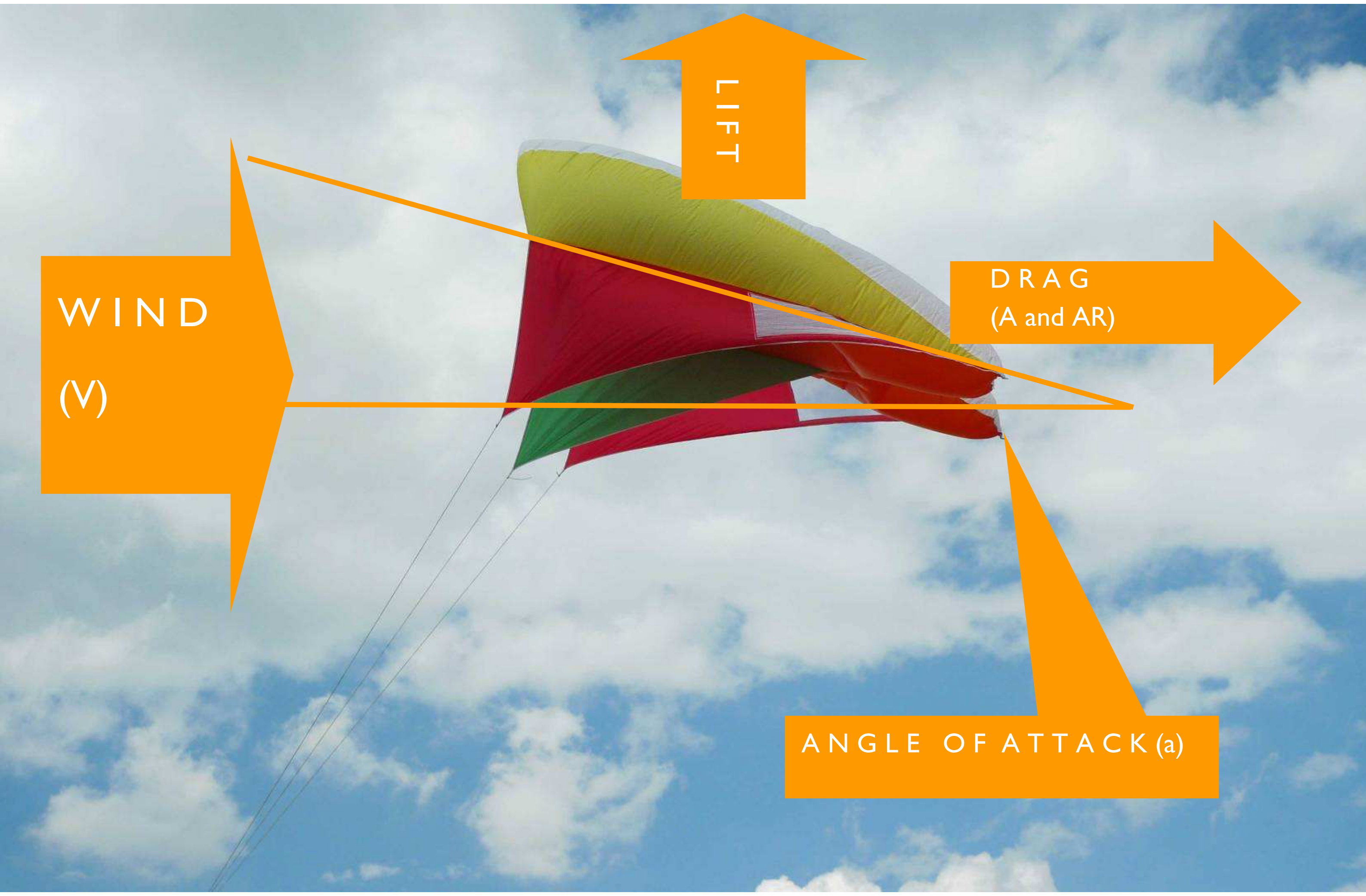
[57] **ABSTRACT**

A flow form device of the type used primarily to maintain both vertical and horizontal stability and maneuverability in a predetermined fluid environment. The flow form device basically comprises four structural elements of interrelating shape and construction to define a predetermined configuration. Additionally, a plurality of Jordan clusters are formed in the first and second skins, and a plurality of holonomic ports are formed in the third skin to maximize the stability and maneuverability characteristics of the device. Primarily to enhance the horizontal and vertical stability and maneuverability of the device, a jet port is formed along a trailing edge of the device. Finally, a jiro port is formed in the second skin in communicating relation with the jet port.

36 Claims, 9 Drawing Figures



The 2 key US patents for 'soft' kites:
Left Jalberts revolutionary parafoil filed in 1966 and Right Steve Suttons flowform adaptation of it granted in 1975.



A simple model of a kite in flight can be seen as a balance of 3 forces: airflow (m/s) lift (N) and drag (kg/m2). It is possible to calculate the available lift for a kite at a given wind-speed using the Lift equation:

$$L = Cl \times A \times r \times (0.5\, V^{2})$$

Where
L = Lift
Cl = lift co-efficient for a low angle of attack given as [(2 π) a]
a = angle of attack (in radians) (180 degrees equals pi radians):
V = wind velocity
r = standard air density value (given at sea level as 1.229 kg/m^3)
A = Area of kite active surface (m^2)

In addition the kite shape and downwash effects of 'spilling' the air around the kite need to be taken into account. The co-efficient value for 'CL' needs to be modified:

$$Cl = Clo / (1 + Clo / (\pi\, AR))$$

Where

Clo = Ist unmodified co-efficient [(2 π) a]
AR = Aspect Ratio of kite (defined to be span 's' squared divided by the area 'A')

I use 260m of 110kg (250 lb) test Dacron and 500m Climax 'Powerline Extreme' Coramid 250kg (500=lb) on 10" 'Halo' spools.

Rough guide to required line breaking strain:
Work out the approximate wing area in square metres (FF30 =2.7m^2) Multiply this figure by 30 for light winds, 50 for normal flying, and at least 80 for breezy conditions - to get line breaking strain in kilos.

"While some experienced fliers manage with one reel-and-line for everything, they are careful to select the right kite for the wind, much as a golfer chooses the right club for a given shot. On the other hand, if you have only one kite, then you will need light line for the light wind end of its wind range, heavy line for the strong wind end, and perhaps an in-between line for in-between winds. There's really no way around this; light line may simply snap in a strong breeze, and heavy line will weigh the kite down in light winds. If the line starts "singing," then it's time to get the kite down fast, before getting into serious trouble. If the line's too heavy, there will be a pronounced "belly" in the line and the kite won't reach much of an angle." Dan Leigh

Managing the flying line
The theory is simple, spool out line as the kite asks for it and wind it in when you're done, flying a kite is simply a matter of keeping an even tension on the flying line, pay it out on the way up pull it back on the way down. In practice the line will burn your hands, be impossible to keep hold of and tangle more readily than hair on a brush. Looking after the line is an aspect of kite flying that demands patience, good quality flying line is hard won and needs to be looked after.

Avoiding tangled line

There is a natural tendency to wind in the kite hand-over-hand which imparts an ever tightening twist to the line, especially in light winds when line is hauled in quickly. This twist causes the line to wrap around itself and tangle.

There are 3 steps to avoid getting the twist in the line:

- Lay the line in several small piles rather than a single heap as you haul in.
- When the kite is down, pull out the line from the *kite end* to un-ravel the spilled line, if you work from the reel end you will be pulling the line out from the bottom of the pile and it will jam. Lay out the line as straight as you can.
- Wind in the line with the reel in your left hand if you are right handed (in your right if you are left handed), this feels awkward (which means you are doing it right!) but this reverses the twist made by the hand-over-hand winding at haul in.

Using a fishing line swivel at the kite bridle is not recommended, they do not have sufficient strength to take the forces involved with a KAP kite under load.

Gloves

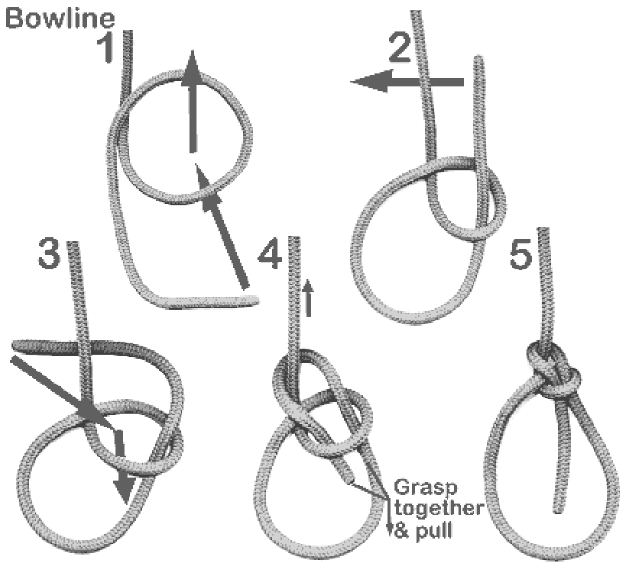
I cannot stress enough how important gloves are: if you are flying a kite which you expect to pull a camera into the air you will cut, burn and probably permanently damage the nerves in your fingers unless you protect your hands. Gloves will give you better grip on the flying line, allow you to pay out line as the kite demands it and give you more time to secure the line than with bare hands. As all the force of the lift of your kite is applied through the cross-section of the flying-line the pressure at the point of line anchorage is huge! Flying gloves of leather are best and they must be replaced when your flying line is felt against the skin of your hand, they are never going to be fashion wear but you must never be without them. Line burn is a risk even when your kite is on the ground, when winding in the line your gloves save your hands.

Knots

There are 2 knots I had to learn:

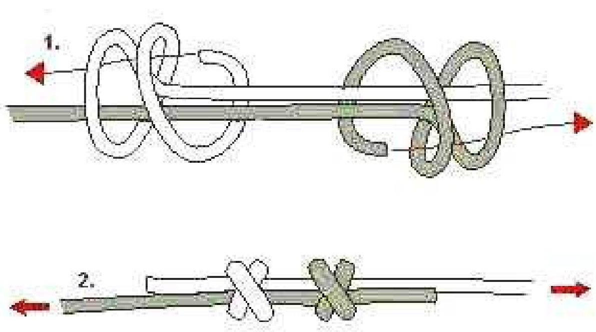
The Bowline to tie the kite to the flying line

http://www.animatedknots.com/bowline/index.php?Categ=climbing&LogoImage=LogoGrog.jpg&Website=www.animatedknots.com



The double fisherman's bend (also known as the grapevine) to join lengths of line together: this knot has been tested extensively and found to have the greatest strength; it can be tied as a triple or more if need be.

http://www.animatedknots.com/doublefishermans/index.php



Damage to line

Even the best quality line will suffer damage from friction. If the line is caught on anything it must be inspected carefully for damage, if there are any signs of wear to the line cut out the damage and tie the line with the fisherman's bend.

Spool types

A simple 'Halo' ring provides good storage for the flying line but tends to place a twist on the line when winding in. A spooling reel (e.g *Stratospool*) is an alternative but spools will fail after repeated use as they are crushed by the compound forces of the tensioned line. The reel must be able to take the stress of winding in the line under load, this can be considerable and consequently mechanical winders that can cope are big bulky affairs the, best of which are known as 'Deep sky' Reels with 12v power types such as the 'Kristal 635 Variable Speed' an option for vehicle or boat mounting.

Harness

A harness lowers the pivot point and distributes the stress of the flying line load across the hips of the flier thus providing a stable attachment for the kite line. A quick release method of attachment (such as a mountaineer's 'figure of eight' descender) is desirable as the kites demand for line should not be unnecessarily impeded. As the load often fluctuates a caving harness is preferred as it is designed to take a greater amount of abrasion than climbers. Using a harness for kite flying takes practice, it may not always be needed but the flier must be able to use it safely without compromising the control of the kite.

THE 4 KITE FLIGHT

To cope with a variety of wind speeds a selection of kites is desirable, the objective is to have a flight of kites that will cover a full range of wind-speeds and still lift the rig. The flight described here is based on my own experience: there are many options! My choices are made on how easy it is to carry them around on a bicycle and how easy they are to assemble and launch. The Sutton Flowform 30 is by far the most used kite of the 4. They are all 'off the peg' kites building your own is fun (the 'soft' kites are quite difficult though) but you will need to be very confident in your work if you are going to trust a precious camera to your handicraft.

	KITE		WIND SPEED *to lift 1kg rig*			
			AR E A	mph	kph	Bft
	Colours in Motion 'Lifter' Parafoil	♦ Flexibility: Light winds only. Flown on light weight 'Powerline Extreme' Coramid line to maximise lift. ♦ Stability: tends to weave a bit compared to the flowforms. Dangerous in overblown state. Must be drogued to reduce tendency to inversion. ♦ Handling: it's a difficult kite in wind speeds above 7mph! ♦ Robustness: Shroud-lines need to packed carefully to avoid tangling.	4.0m^2	5-7	8-11	2
	Sutton Flowform 30, 'Becotised'*	♦ Flexibility: flies across a wide wind range (3.5 to 16mph). ♦ Stability: good in most conditions, must be dampened with a drogue to deal with gust. ♦ Handling: can be a pain to launch in light wind and is very susceptible to collapse and inversion in rotor and vortex effects. ♦ Robustness: very hard to break but stitching needs checking if over-flown in high wind speeds (16mph+).	2.7m^2	6.5-12	10-19	3
	HQ Flowform 2.0, 'Becotised'*	♦ Flexibility : Fly in fresh winds only. ♦ Stability: Always flown with a drogue- dreadful in near ground turbulence. ♦ Handling: Copes with Beaufort 4 easily, its weight balances its pull nicely. ♦ Robustness: It's made of heavy weight fabric so it is heavy (therefore rubbish in light winds) but robust.	2.0m^2	12-20	19-32	4
	Paul's Fishing Kite 'Nighthawk' Delta	♦ Flexibility: rated at 5-40 knots (6-46mph, up to Bft7!) won't lift a rig until flown in at least 15mph. ♦ Stability: tends to dance about at launch and landing, takes high wind speeds well. Twitchy. Flown with shock-cord damper below kite and above rig. ♦ Handling: typical delta- needs care on recovery, noisy! ♦ Robustness: Well made from heavy duty materials, awkward to transport.	1.06m^2	15-30	24-48	5

*modified according to aerodynamic research by Christian Becot for increased stability http://www.becot.info/tako/anglais/e&tako_1.htm

WIND

Understanding Airflow
The basic principle of the kite is simple: the drag imparted by its surface is converted to lift by the angle of attack of the kite, provided the mass of the kite and its line are less than the pressure of wind acting on its surface. Getting to know what to expect in a given set of conditions takes time and it is this experience which marks out skilled kite fliers; they know how to get the best out of the wind because they have learnt to match the wind-speed to a kite adapted for it, they also know when the wind tells then to go and do something else.

Man and wind
Making the wind work for you is something millers and sailors have, within the limits their capacity to harness nature, mastered. Understanding the limits and the consequences of ignoring them is vital; a kite can multiply the force of the wind by close to the cube of its area: our ability to handle such forces safely is crucial to avoid injury or loss of life. Ships have been dis-masted, crews sacrificed, mills have been wrecked with harvests laid waste and mountaineers lost when the wind is not given the respect it deserves.

Wind is not a continuous force, it constantly fluctuates in waves, the nature of the forces caused by airflow shift constantly and using the wind to gain a stable platform is something of a fool's errand, however, in pursuit of a unique vantage point for a camera, a good kite and a well designed rig can mitigate a lot of the inherent instability in the balance of lift, mass, turbulence and camera performance.

Aerofoil effects
Parafoil and paraform kites (including flowform designs) have the capacity to exploit the aerofoil effect caused by their shape and angle of attack. The Bernoulis theorem famously states:

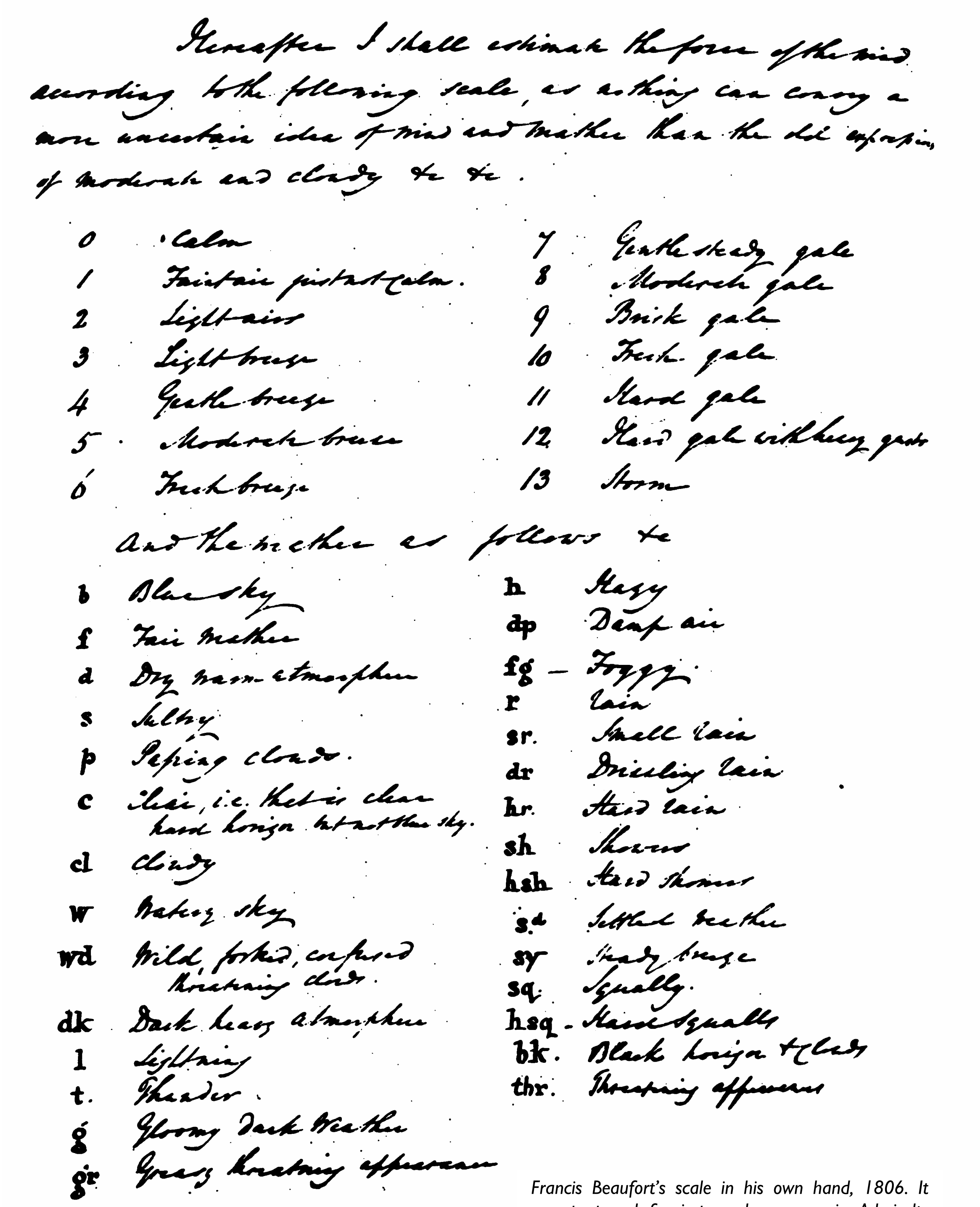
'As air passes below the wing it also passes above the wing. The air on top of the wing moves a longer distance over the curved surface of the wing and moves at a faster speed. This reduces the pressure above wing. The air below the wing moves slower than the air above the wing. This causes the air pressure to be increased. This difference in pressure above and below the wing causes a wing to fly or lift.'

Flying an aerofoil is thrilling as the lift generated happens immediately the airflow allows it and the flier must respond accordingly, the sport of power kiting centres on this effect. For KAP the aerofoil effect gives more lift for a given wind speed than a simple sail but in light winds this effect is absent.

Sutton Flowform 30 in 15mph wind, the heeling should be controlled with a tail or drogue.

BEAUFORT SCALE

Force	Anemometer reading mph	kmh	m/s	knts	Description		Effect on kite
0	0-1	<1	<0.3	0-1	Calm; smoke rises vertically.	Calm	Launch frustration
1	1-3	1-5	0.3-1.5	1-3	Direction of wind shown by smoke drift, but not by wind vane.	**Light air**	Very large deltas and foils may fly
2	4-7	6-11	1.5-3.3	4-6	Wind felt on face; leaves rustle; ordinary vanes moved.	**Light Breeze**	Sutton ff30 lofts 500g at 3.5mph
3	8-12	12-19	3.3-5.5	7-10	Leaves and small twigs in constant motion; wind extends light flag.	**Gentle Breeze**	Drogue needed
4	13-18	20-28	5.5-8.0	11-16	Raises dust and loose paper; small branches are moved.	**Moderate Breeze**	
5	19-24	29-38	8.0-10.8	17-21	Small trees in leaf begin to sway; crested wavelets form on inland waters.	**Fresh Breeze**	Reduce kite size / increase drogue size
6	25-31	39-49	10.8-13.9	22-27	Large branches in motion; whistling heard in telegraph.	Strong Breeze	
7	32-38	50-61	13.9-17.2	28-33	Whole trees in motion; inconvenience felt when walking.	Near Gale	KAP not possible with out severe risk of injury to operator and equipment.
8	39-46	62-74	17.2-20.7	34-40	Breaks twigs off trees; generally impedes progress.	Gale	
9	47-54	75-88	20.7-24.5	41-47	Slight structural damage occurs (chimney-pots and slates removed).	Severe Gale	
10	55-63	89-102	24.5-28.4	48-55	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	Storm	
11	64-72	103-117	28.4-32.6	56-63	Very rarely experienced; accompanied by wide-spread damage.	Violent Storm	
12	73-83	≥118	≥32.6	64-71		Hurricane	


Hereafter I shall estimate the force of the wind according to the following scale, as nothing can convey a more uncertain idea of wind and weather than the old expressions of moderate and cloudy &c &c.

0	Calm	7	Gentle steady gale
1	Faint air just not calm.	8	Moderate gale
2	Light airs	9	Brisk gale
3	Light breeze	10	Fresh gale
4	Gentle breeze	11	Hard gale
5	Moderate breeze	12	Hard gale with heavy gusts
6	Fresh breeze	13	Storm

And the weather as follows &c

b	Blue sky	h	Hazy
f	Fair weather	dp	Damp air
d	Dry warm atmosphere	fg	Foggy
s	Sultry	r	Rain
p	Passing clouds.	sr.	Small rain
c	Clear, i.e. that is clear hard horizon but not clear sky.	dr	Drizzling rain
cl	Cloudy	hr.	Hard rain
w	Watery sky	sh	Showers
wd	Wild, forked, confused threatening clouds.	hsh	Hard showers
dk	Dark heavy atmosphere	sd	Settled weather
l	Lightning	sy	Steady breeze
t.	Thunder	sq.	Squally.
g	Gloomy dark weather	hsq	Hard squalls
gr	Greasy threatening appearance	bk.	Black horizon & clouds
		thr.	Threatening appearance

Francis Beaufort's scale in his own hand, 1806. It was prepared for improved accuracy in Admiralty records and incorporated ideas from the lighthouse engineer John Smeaton.

In general up to Beaufort force 5 is safe to fly a KAP kite, anything over that and SERIOUS PROBLEMS MAY OCCUR. The exceptional design of fishing (e.g. Paul's Nighthawk) kites can handle more but strong winds are turbulent; you will find lift will suddenly fail and, as you begin your recovery, the pull suddenly becomes uncontrollable often catching the kite out of balance with the risk of 'power dive' ending all!

Beaufort 2, 3 and 4 (between 3.5 to 15 mph) is my comfort limit; Beaufort 5 can be managed with the right kite if the gust or peak speed is less than about 22mph.

Variation in airflow:

Weather system characteristics

Wind is a dynamic force it is never constant and can pulse in power (gust) over a variety of cycles. Gust patterns can vary they have a maxima of up to twice the nominal wind-speed and minima of no variation other than a few percent of the average. Big gust effects are common in cyclonic conditions and less so in anticyclones.

Local effects:

Rotary turbulence is caused by almost any obstruction to airflow; it is also triggered by channelling effects under bridges along cuttings and embankments. A ditch across an apparently flat field can produce a disruption to a smooth airflow if the wind direction is either along it or directly across it.

Laminar flow is the characteristic of a smooth flow, the higher up you go the stronger the wind! It is common to have a very turbulent lower layers and increasingly smooth layers above.

Buildings create difficult airflow to fly in, this includes very dangerous shear effects: in order to photograph buildings close up a long lead line should be let out before the camera is launched.

Trees in leaf create disturbances in the airflow up to 3 times their own height.

Matching the kite to the airflow

By using a drogue the lift /drag characteristic of the kite is altered, this can effectively extend the high end of the wind range of the flowform pattern kites successfully. Although the turbulence of some airflows is unmanageable the drogue exerts a dampening of the lift by adding a drag force that is constantly proportional to the airflow through it.

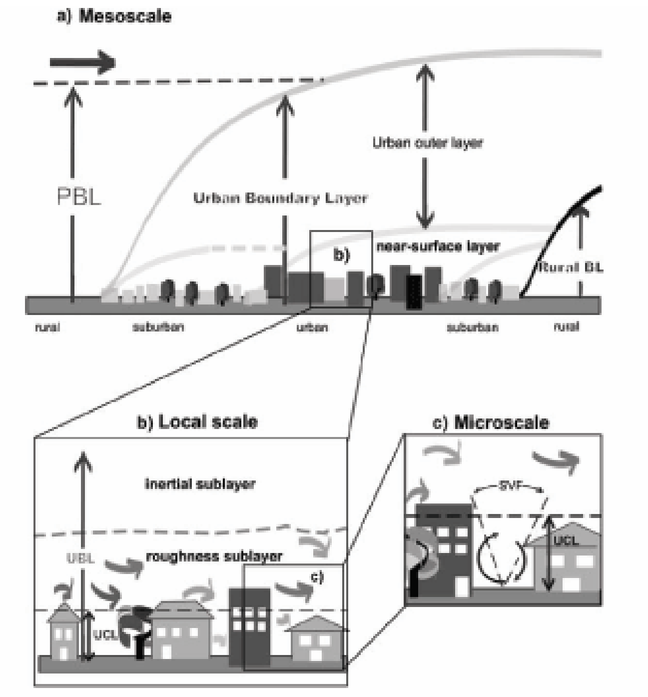
SUTTON FF30 (2.7m^2) : APPROXIMATE LIFTING CAPACITY

Minimum mph	Beaufort	Lift	Flying Angle	Camera	Peak mph Gust
3.5		Lifts kite and line alone	Low (30deg to ground)		6
6	2	Lifts 700g rig	Low (30deg to ground)	Canon Ixus	8
7		Lifts 850g rig	High (45-50 deg to ground)	Panasonic LX3	12
8	3	Lifts 920g rig	Low (30deg to ground)	LX3 Camera with wide angle lens adaptor	13 (drogue required)

HQ 2.0 (2.0m^2): APPROXIMATE LIFTING CAPACITY

Minimum mph	Beaufort	Lift	Flying Angle	Camera	Peak mph Gust
6	2	Lifts kite and line alone	Low (30deg to ground)	Panasonic LX3	8
7					12 (drogue required)
8	3	Lifts 700g rig			13 (drogue required)
12		Lifts 850g rig	High (45-50 deg to ground)		15 (drogue required)

The boundary layer



In the Earth's atmosphere, the planetary boundary layer (PBL) is the air layer near the ground affected by diurnal heat, moisture or momentum transfer to or from the surface. In physics and fluid mechanics, a boundary layer is that layer of fluid in the immediate vicinity of a bounding surface.

The boundary layer is the layer a kite flies in. The height of the boundary is varies according to wind-speed, location and pressure, kites will rarely escape the PBL (with the exception of marine and artic environments) consequently an understanding of how turbulent, non-laminar flow affects the behaviour of the kite is important.

Layers in the boundary layer

In the planetary boundary layer turbulence is produced in the layer with the largest velocity gradients that is at the very surface proximity. This layer - conventionally called a surface layer - constitutes about 10% of the total PBL depth. Above the surface layer the PBL turbulence gradually dissipates, losing its kinetic energy to friction as well as converting the kinetic to potential energy in a density stratified flow. The balance between the rate of the turbulent kinetic energy production and its dissipation determines the planetary boundary layer depth. The PBL depth varies broadly. A given wind speed, e.g. 8 m/s, (18 mph) will have a co-responding local rate of turbulence production, such that a PBL in wintertime Arctic could be as shallow as 50 m, a nocturnal PBL in mid-latitudes could be typically 300 m in thickness, and a tropical PBL in the trade-wind zone could grow to its full theoretical depth of 2000 m.

In addition to the surface layer, the planetary boundary layer also comprises the PBL **core** (between 0.1 and 0.7 of the PBL depth) and the PBL top or **entrainment layer** or **capping inversion layer** (between 0.7 and 1 of the PBL depth). Four main external factors determine the PBL depth and its mean vertical structure: (1) the free atmosphere wind speed; (2) the surface heat (more exactly buoyancy) balance; (3) the free atmosphere density stratification; (4) the free atmosphere vertical wind shear or baroclinicity.

http://en.wikipedia.org/wiki/Planetary_boundary_layer

PROCEDURE

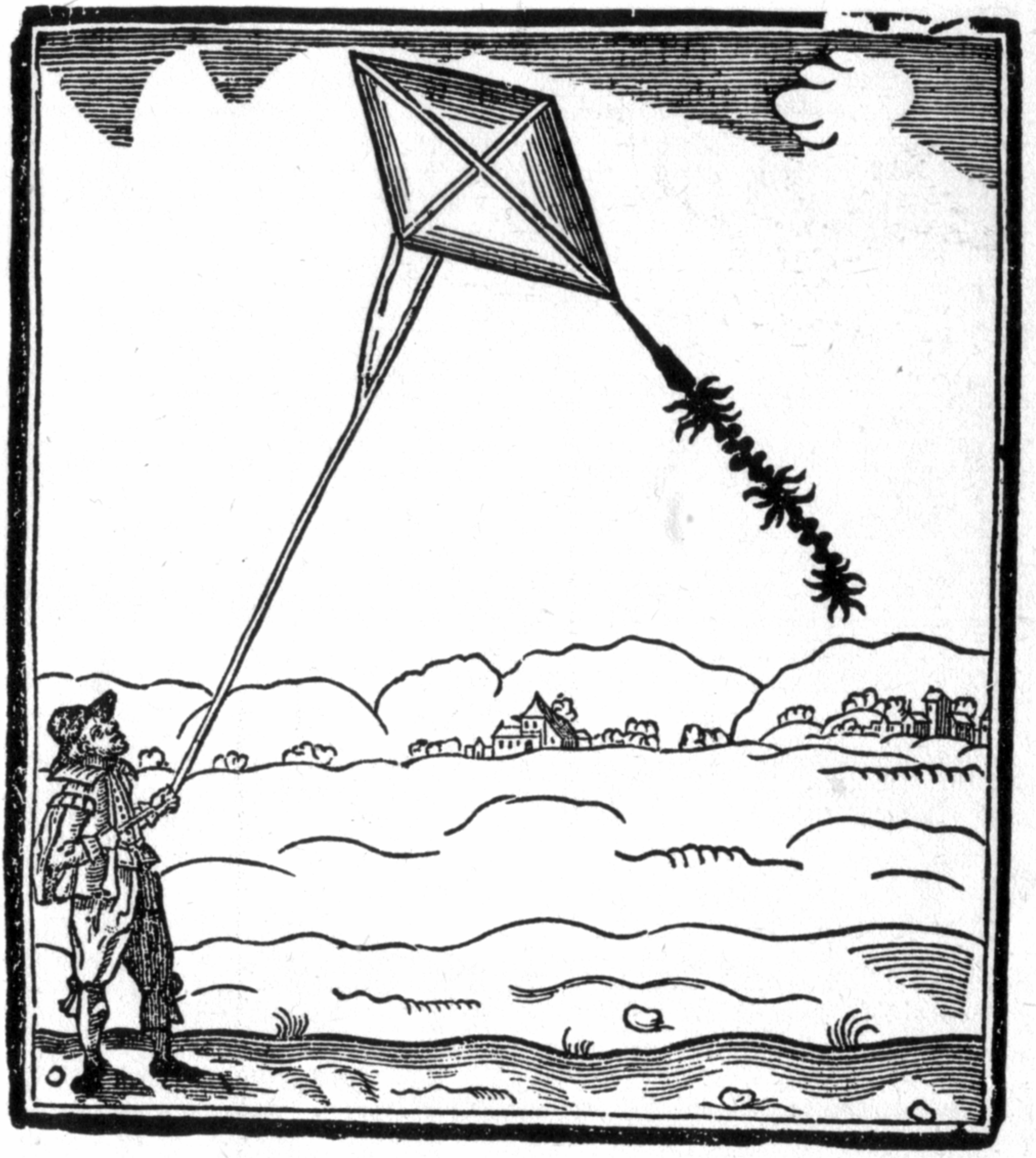


Illustration from John Bates 1634 'Mysteryes of Nature & Art' description of a 'Fiery Drake' (fire dragon) or firework lifting kite. Copyright: British Library

Basic kite dynamics:

- Large kites are inherently more stable than small ones.
- A correctly sized drogue or tail stabilizes the motion of a kite.
- Symmetry is all. A kite out of balance is a disaster waiting to happen, get it down and balance it!
- Kites that 'spill' airflow (by allowing a portion of the flow to pass through them) will do better at higher wind speeds than simple sails.
- Soft kites fare better than framed ones with higher wind speeds as they have no spars to break BUT unless properly designed buffeting can close cells and cause a soft kite to collapse.
- In light winds the weight of the line can cancel the available lift
- Under load (i.e. lifting a rig) the bridle angle will be steeper than without loading.
- There is an optimum angle of attack for any given kite which is the angle where lift overcomes drag. In other words the angle at which the kite is blown upwards against the restraint of the line not along.
- Sudden load increases caused by gusts mean the flying line must have a tested breaking strain which should be at least double the anticipated load.
- A spool reserve (and space to use it!) is needed for kite control as the attitude of a kite under extreme stress can only be corrected by reducing the forces in it: without slack line to pay out you will be forced to run towards the kite.

Matching kite to wind speed:

There is no one kite that will fly in all winds. In theory a big light kite will lift best in light winds and a smaller strongly built one will be best in stronger winds: in practice the range of wind-speed for a given kite can be extended a bit by adding a drogue or tail (with some loss of flying angle). The increase in pull caused by gusts in stronger winds can be catastrophic for a large light-weight kite.

(Adapted from Tgran posted on flickr)
'All kites have their wind ranges (from barely lifting to out of control). In calm breezes (where it's easiest to learn this stuff) the FF8 is a little bit of a toy. Its fun, but it won't lift your cell phone consistently. I'd get (or build) a fled kite as it will be more generally useful in the 6-13 mph wind range. You really will need a 12 mph or so breeze to get the FF8 + rig off the ground and if the wind is rough it won't be good for the longevity of your camera. It's much harder to learn this stuff toward the upper end of the wind range.'

Up to Beaufort force 5 is safe to fly a KAP kite, anything over that careful consideration of the behaviour of the kite is needed otherwise SERIOUS PROBLEMS MAY OCCUR.

Strong winds are turbulent; you will find lift will suddenly fail and, as you begin your recovery, the pull suddenly becomes uncontrollable often catching the kite out of balance with the risk of 'power dive' ending all!

FLYING

The fliers' stance of stiff neck and hunched shoulder as depicted in the picture of the 'firey drake' will be familiar to modern day fliers. Relying on the grip of your hand (preferably gloved) when flying a kite with sufficient pull to lift a camera is risky in all but the lightest winds; use of a harness is recommended.

Key points:

- Be patient
- Assess hazard and risk to you, your kite and those around you
- Make sure you have room to move
- Get a feel for the wind where you are
- Test the lift above your local envelope before you commit the rig aloft
- Watch the kite at all times
- Know when to give up and try again on another day

FLYING FOR PHOTOGRAPHY

The time of day and state of sunlight are crucial to success. Consider the effect of :

- Grazing Light, early morning, late evening (also be aware that lift changes at these time too!)
- Midday lighting, summer and winter
- No sun, overcast skies may give a useful flat light in some cases
- Camera settings and filters to balance sky and ground illumination

LAUNCH

When conditions are right it's simple but it can try your patience when you are unfamiliar with the airflow. Watch for any sign of the nature of the flow…..place yourself as far from obstructions as possible…find the 'sweet spot' where you are away from vortices and in a clear airflow. Stand with your back to the wind, let out line and pull back on the kite; enjoy the thrill of flight!

Know your kite
Some kites are very unstable until they have achieved the correct angle of attack; they loop madly, demanding slack line as the kite begins to turn over and then tight line as it is upright until balance is achieved. Typically you will have to dance with the kite moving quickly in the first seconds of launch and then less so as the kite corrects.

Know the site
If you are attempting to photograph buildings beware the effect the building will have on airflow. If the launch site is surrounded by trees and buildings you may well be standing in a place the kite can't be launched from!

Know the wind
Light is good, strong is bad; you need to know just how light a wind your kite and rig will work in. Always spend a little time to assess the available lift with your chosen kite before committing the rig to the flight. If you have a selection of kites available you will be able to match the best kite for a range of wind-speeds.

Know your rig
Be ready with the rig and make sure it will lift cleanly, don't try to winch it by pulling the kite up, if you have to resort to running backward pulling the kite to lift the camera you have probably committed in too light a wind. As the rig ascends its mass will affect the attitude of the flying line to the kite, be ready for this; the effect can be violent and start an unwelcome cyclic oscillation, if your rig suspension is properly designed the movement should dissipate quickly.

Clothing
Wear gloves!

Wear a harness or climbers sling with a 'figure of eight' descender and a ratchet.
You are going to stand in the wind, wear appropriate clothes.
Keep a knife in your pocket.
You are going to be staring into the sky for longer than normal: wear shades.
Once you have the kite aloft you will probably be unable to put more clothes on or take any off, be ready to make the best of what you are wearing once you have committed the kite to the wind!

FLYING HEIGHT

It is not a straight forward matter to determine the height of a kite above the ground. A rough method is to use a clinometer to determine the vertical angle to the kite *(θ)* and estimate the hypotenuse *(h)* as the length of the flying line with the accepted catenary of the line as giving a false reading of *(Sin θ)h*; the method has the benefit of simplicity but it is not accurate.

The GentLED 'altiOSD' altimeter.

A light weight altimeter which will relay height data as an onscreen display via the camera video-link is available from James Gentles:
http://www.gentles.ltd.uk/gentvu/altiosd.htm

HANDLING THE FLYING LINE

The tension must be constant and the kite will rise against the line, avoid sudden tugs and play out the line as fast as the kite demands it, height is safety so don't try to attach the camera until the kite is well into a smooth airflow with a

constant pull against you, adding the rig to the line will pull it down so you must estimate how much lift there is and balance it against the mass of the rig.

LINE RECOVERY

Winch/haul down

Given the right lift to load ratio, it is possible to haul line fast enough for the kite to maintain lift and get the rig back safely almost every time. This technique works very well for small kites and light rigs.

Aside from calamitous drops of wind, hauling the line down at the end of any KAP session can be very therapeutic and in difficult conditions is the fastest way to get the kite down through a turbulent transition zone with control on giving and taking line if the kite misbehaves.

Spread the line out as it spills to avoid a single heap of loose line by paying it out in zigzags on the ground. Walk towards the kite drawing the line in as the pull slackens then grip the line and walk the kite upwind to begin the walk again.

Lastly, line grip when hauling. This is the bit I thought intuitive, but I've seen quite a lot of other fliers do not do this. To greatly reduce the risk of line slipping, and potential line burn, (but you are using gloves aren't you?) as you grasp the line turn your hand 90 degrees towards yourself as you haul. If you've not tried this, you will be surprised at the improvement in grip on the line. Although there is a risk to your hand if the pull is too strong, taking a half turn of line over your hand will give you enough grip to momentarily shift the free hand to tie off the line or advance up the line, this needs careful judgement and flies in the face of the 'never take a turn around your hand' sailors rule: always be ready to free your hand in a gust!

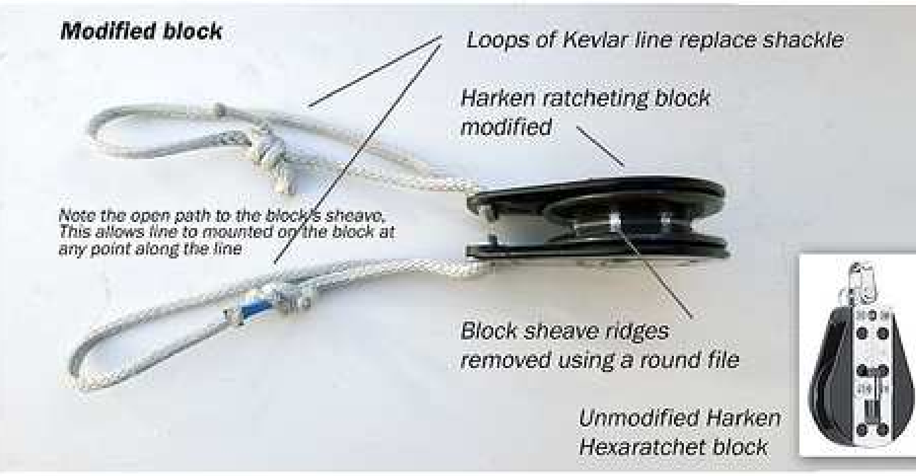
Adapted from Simon Harbord at
http://steel.ced.berkeley.edu/cris/kap/discuss/comments.php?DiscussionID=907

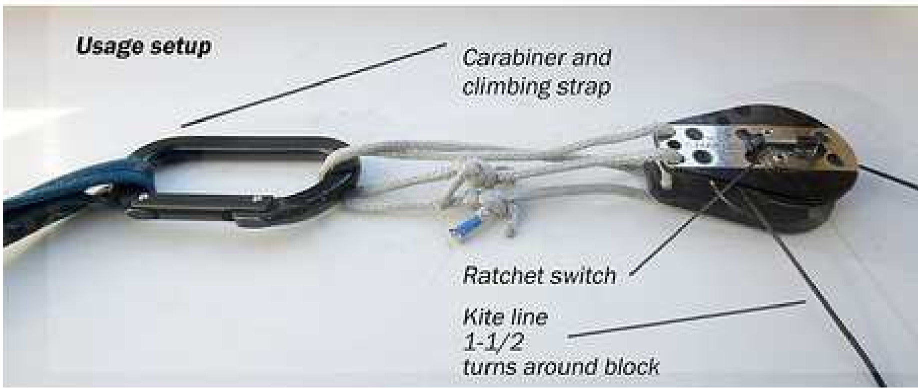
Walk down

If space allows and you are confident the line length between you and the kite will fit in the space you are in with out fouling obstructions then anchoring the line and walking down it sliding the line under your hand using a glove, strop or pulley will bring down the kite easily, Take care to avoid abrasion or sudden release of the line as the tension can offer fierce resistance to any object used to slide along it. Be careful to let heat dissipate clear of the line, keeping the traveller moving will avoid this.

Damage to flying line

Check for wear at the attachment points for the rig and tie off, its surprising how often these occur at the same points on the line and cause abrasion. Take care to anchor the line clear of sharp edges and inspect it when untying for marks that could indicate stretch or wear.





A modified ratchet block is an extremely useful tool in recovering the kite. If the wind speed increases with the kite aloft getting it back down again can be difficult. Chris Benton found a racing dinghy ratchet block was perfect for the job after the modifications shown. Photo diagram by Chris Benton.

KAP Field Practice & Procedure

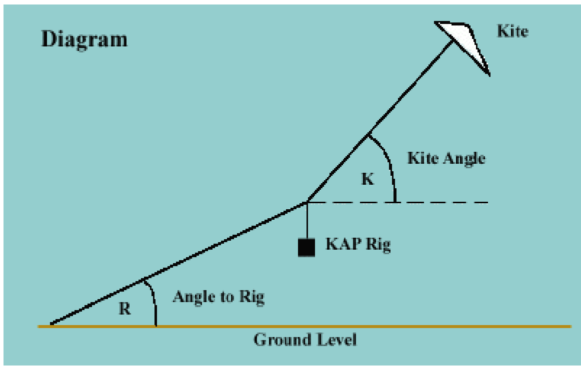
Having got to the flying field some important decisions must be made. Having a number of targets in mind is useful, if one site doesn't work out having an alternate could save the day. Pick your day on the basis of the best forecasts available, you need wind and sun for this! If you are working as a pair procedure will be different than working solo, if extra hands are willing they can be put to good use carrying kit, swapping camera control, keeping spilled line tidy or even as 'foreground' interest in photos!

Remember there is no shame in calling off a flight if you are not comfortable with any aspect of what you propose to do: your kite, camera and photographic standards are not worth risking.

Wind, light and viewpoint

The view downwind will be easiest to work with, there will be a good match between what you see on the ground in that direction to what the camera sees. The view directly upwind will tend to include the flying line. Illumination is crucial to success and strong light will generally give better results than soft. Sunlight on the subject is desirable, sun at right angles to wind direction give good results. Shooting into the sun can give dramatic effects but glare problems will be grater for an airborne camera as the horizon will ten to be 'wider' than a ground based one, for this reason a polarising filter should be used. The exposure of clouds will be improved and the 'flare' from ground reflectance will be reduced with a polarising filter. Lower sun angles will always be more interesting than higher but at the cost of lost information in shadow.

In preparation for a KAP flight the following steps have proved successful.



1. **Assessment** of the launch site, wind conditions and downwind view of target. Wind at your back with Sun to the Left or Right is ideal. You may find the wind direction and sunlight won't let you do what you want to…pack up and try again later, nothing you can do will change the weather, pay more attention to the forecast next time! A bit of map work before you set out will pay off on the day.

2. **Time,** do you have time to achieve what you want to do? KAP is best not rushed, you will only have mediocre results if you do not 'feel' your way into the wind, and that takes time. Waiting for the light will pay off if the forecast justifies it…waiting in hope is a fool's game!

3. **Alternate launch site**. Consider alternative lunch site and walk-in options, you may well start off in an easy launch site but have your path to the target blocked. It's far easier to walk the kite down wind (it will be in front of you) but the walk *opposite* the launch site may give you an easier walk in.

4. **Check available resources**, tie-off points, people who can help. If you are working solo you will have to be fully kitted up with harness, knife, dog-stake and recovery gear *before* launch.

5. **Assess risk**, check for overhead obstructions, wires, trees, poles and posts, traffic (cyclists are very vulnerable to kite line), animals (horses are spooked by a low flying kite, be prepared to down the kite and let riders pass), people, air traffic, wind direction variation. Distraction hazard is worth considering, will your kite attract the attention of anyone who should be concentrating on something safety critical like driving a car or operating a chainsaw?

6. **Kit prep**, select
   - kite and drogue,
   - rig: AutoKAP vs. full control,
   - camera: heavy or light,

   according to what will work in the available wind. Lugging a selection of kit gives you more options: Having an AutoKAP rig, an alternate lightweight camera, high and low wind speed kites, drogues etc. all extend the chances of success.

7. **Protect your kit** from dirt and damp as much as possible, pack away and carry with you anything you don't use, the chances are you may not return to the same spot once you are airborne, the old survey adage 'never turn your back on your kit' is true for KAP, once the kite is aloft your concentration will be focussed on other things. Don't forget a systematic method of putting stuff away in the same place will strengthen your chances of not missing a vital component next time you need it.

8. **Assemble rig**,
   - attach pendulum, examine mounting point: ANY evident damage at this stage should abort the flight.
   - attach antennae, a 3 point fixing is needed for the RC Rx antenna
   - observe Tx/Rx power on priorities: RC Tx must radiate 1st!
   - check camera and shutter actuation, adjust PL filter to horizon opposite sun, set burst mode,
   - connect camera to video relay,
   - power up and connect receiver and screen, test signal, remove lens cap
   - zero altimeter.

9. **Pilot launch**: If uncertain about which kite to use launch one and see how much pull there is in the 'clean' air to confirm your choice. Never launch the rig unless there is sufficient lift!

10. **Let the kite find its lead length.** If the wind is light let the kite rise until you feel the pull is enough, and then let it rise a little more in anticipation of the weight of the rig.

11. **Brief team**, when you are happy with the behaviour of the kite it is a good time to advise all involved on the risks before you commit the rig, After all you are about to hang a weight above their heads!
    - The more people know about what's going on the happier they are (although you don't want to be the centre of a crowd scene).
    - In most cases the biggest risk to immediate bystanders is line burn during launch and landing.
    - Let people know where they can see the results; it does no harm and engenders a friendly attitude.

12. **Attach assembled rig to flying line.** Get some slack ahead of the desired mounting point. Check for abrasion risk on the cleat. Attach cleat end upwind, snap clip over the flying line.

13. **Clothing**, do all the team look like they will be able to watch the sky, handle line and survive the weather ok? A good flight will be *hours* long. Gloves, sunglasses, long-sleeved tops, sunscreen may be required.

14. **Permissions**: should you have asked anyone who might object to what you are doing first? Dealing with upset people while you are flying a loaded kite is best avoided; you can't run or hide with a big kite attached to you!

15. **Watch the kite at all times**. Once aloft the kite flier has only one job, keeping the rig safely aloft, all decisions about how this is best achieved are up to the flier. If the air flow becomes unstable or there is a loss lift the decision to get out of the sky rests with the flier.

16. **Move with caution,** there is a sort of slow motion effect of walking with a kite, sudden movement is undesirable.
    - Walking down wind will lower the kite and time must be allowed for it to recover.

- Smooth motion in paying out line will help the stability of the kite
- Reeling in can demand quick action to maintain flight, the flier must be alert to this, especially with a heavy camera.

and finally…
Don't panic! There is a way around most difficulties and the more practice you have the more apparent this is. The rig can be hauled down, the flight called off and lessons learned provided you have the means to recover the kite. It is easy to fall into a rushed state of mind but when the kite is aloft you have as long as the wind is blowing and the batteries hold up to get your shot!

Kite Aerial Photography R I S K   A S S E S S M E N T

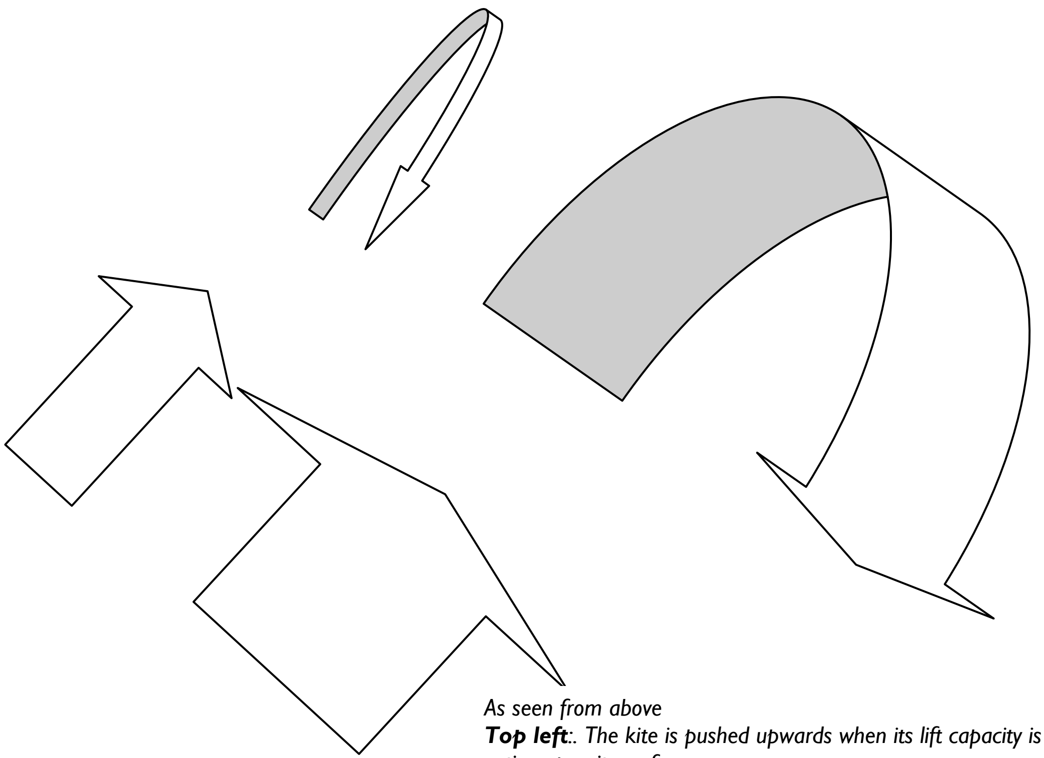
Identify, characterize, and assess threats	**assess the vulnerability of critical assets to specific threats**	**determine the risk** *(i.e. the expected consequences of specific types of attacks on specific assets)*	**Potential frequency**	**Liability for action**	**Organisational , procedural amelioration procedures**
Entrapment of persons by flying line	During launch and recovery.	Persons unaware of sudden tensioned line could receive line burn to exposed parts of the body.	Medium	Kapper /site owner	Restrict access to flying area subject to advice of hazard and personal injury OR suspend kite operations as required. Avoidance of operations during times of public access.
Abrasion of persons by flying line			Medium	Kapper /site owner	
Conflict of kite flying operators and grass cutting/ trimming, tree surgery /landscape management operations.	Personal injury to kite operator. Injury to persons unaware (due to use of power tools) of fall/trip hazards. Distraction hazard.	Serious injury to persons in contact with cutting/chipping equipment	frequent	Kapper /site owner	Restrict access to flying area subject to advice of hazard and personal injury OR suspend kite operations as required.
Conflict of landscape with persons flying kite/operating camera	Stepping backwards in to hazard: rabbit scrapes, embankments, landscape features, waters edge.	Personal injury for fall, immersion,	seldom	Kapper	
Failure of kite line, fall of rig	Loss of equipment	Injury to persons in line of fall	seldom	Kapper	Equipment-check procedure, equipment design, frequent inspection of flying line for damage, access to secure anchor as required.
Damage to monument from contact with rig, flying line or kite.	1kg suspended load impact to monument. Damage or loss of equipment.	Percussion damage,	seldom	Kapper	Operational procedure, flight control
Entanglement or loss of equipment in trees.	Damage to trees Damage /loss of equipment.	Breakage of small branches. Kite unrecoverable from tree.	Medium	Kapper	
Noise of landscape management equipment stops communication between camera and kite operator	Uncontrolled camera direction causes impact to monument.	Loss of camera direction, damage to monument.	Medium	Kapper	Suspend kite operations

Overblown kite

Knowing the limits of kite performance is crucial to matching kites to appropriate wind speeds. Reacting to early indication of an overblown kite can avoid serious problems. A well made kite may well not show any signs of failure before it is overcome by the imbalance of forces acting upon it, being aware of how to 'read' an approaching failure before things get out of hand is well worth the time taken in testing conditions before committing the camera to flight.

What is the overblown condition?
Simply put a kite is overblown when the wind pushes it out of the sky. The early indications of this may not be obvious from the flier's point of view, particularly if using an unfamiliar kite.
Viewed from above a Flowform kite is lifted upward in the down wind direction, an efficient kite with a well matched airflow will rise towards (but hopefully never reach) an over-head position. An increase in airflow will cause progressive instability (usually characterised by the kite 'heeling' progressively harder to the left or right of the down wind axis) to the point where the kite is blown into the ground.

What happens?
It depends on the kite but early indications are a tendency for it to fly 'on its ear', a parafoil will be close to inversion in this state which will happen suddenly leaving the flier with little time to react. Flowforms do better and can tolerate flying in the edge of the wind window fairly well, the tendency to inversion is less that for a parafoil. Generally the kite is pushed down and out to the edge of the wind envelope. It will lose its ability to lift any load as it is forced across the face of the wind. Gusty conditions make reaction to the overblown state difficult; the obvious tactic of giving the kite more line in the hope that it will rise will only add to the difficulty of the situation when the gust releases its pressure on the kite by either placing it in a higher (faster) airflow or further down wind exacerbating recovery.



As seen from above
Top left:. *The kite is pushed upwards when its lift capacity is generated by wind pressure acting upon its surface*

Bottom Right: *An increase in wind speed will eventually push the kite to the edge of the wind 'window'. The kite will heel to one side, it may recover as gusts subside but a heeling kite in a strong wind is a sure sign of too much kite placed before the wind! If the wind-speed continues to increase eventually the kite will be pushed into the ground. Even if they can keep flying framed kites will snap spars and soft kites will rip stitching if exposed to excessive wind speeds.*

The Flowform kite and thermal vortexes

In warm weather light winds thermals can be come the dominant airflow. They are a big problem for 'soft' kites. A thermal has 2 components, a rising column of warm air and a descending flow of displaced cool air around it, the kite will be pulled into the descending airflow as you let out line in search of height. You cannot see the airflow caused by the thermal and they will invert the kite and send it either into a power-dive or into an accelerating descending spiral. Flying with a drogue will slow down the effect but the power of the vortex is sudden and destructive to a Flowform kite.

The obvious action of letting the kite have more line (and reduce the speed of the movement accordingly) works but only momentarily as the longer line, when it takes the load of the new airflow will pull the kite back into the vortex. If possible, as soon as the slack line has allowed the kite to recover its attitude move the kite across the sky as quickly as possible (yes, run sideways across or down wind if you have to) to get the kite back into the clean airflow.

If the kite has a tail or drogue it will recover more quickly but the required action is *to tow the kite out of the descending air as quickly as possible.*

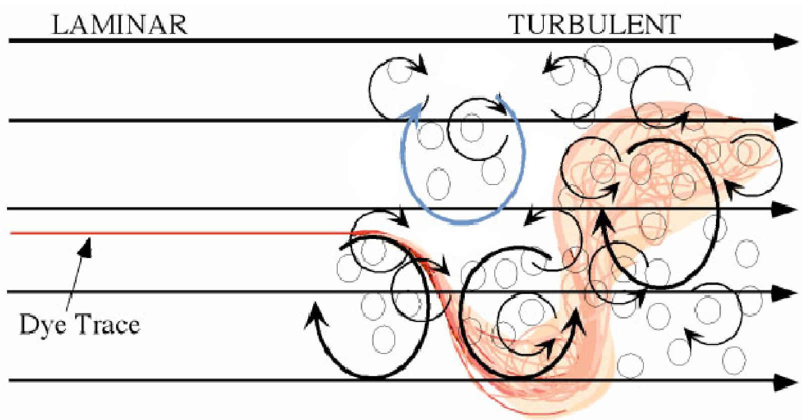
Once in a spin most kites don't recover (and in fact the spin will speed up us you pull it out of the rotor) until they are given slack line to release the energy of the spin. The flier will need to judge carefully how far the kite needs to be dragged (spinning and falling) across the sky before it can be fed line and righted.

A framed kite will behave in a similar way but a soaring delta can be directed into the up draught as it can fly as a free wing in the way soft kites cannot when the forces acting on them are inverted. The diagrams below give some idea of what the kite is up against!

Take a look at the smoke trace of the wing tip vortex spilled by a light aircraft; the size of the disrupted airflow is significant a kite flown into a vortex like this has almost no chance of recovering normal flight unless it is removed from the flow.

In the flow diagram, the dye trace reveals the rotary nature of the turbulent flow. When flying a kite there are no such markers. The first indication you get of the rotor is when the kite rolls over and starts to spin.

The causes of turbulence are either *local obstruction* to airflow (buildings, trees hilld etc.) or *thermal displacements* cause by differential heating or cooling of the air.



R I S K

Craig Wilson's list of do's & don'ts for flying in an urban setting.

D O N 'T

1. TAKE CHANCES: Never launch into unknown winds. Fly first in a safe, open area so that you know the true wind condition at the heights you will have the kite. The scariest thing would be to have too much kite for the wind up over buildings and traffic.

2. FORGET YOUR RECOVERY KIT: Never be without all your hardware for recovery, tie down, and line handling. Keep all you need with you. Don't leave it in the car. Don't leave it with a friend to hold. Don't leave it on the park bench where you launched thinking you won't need it till you get back.

3. PUT PEOPLE AT RISK: Never launch or land a kite in an area crowded with people. Launch away from the crowd and walk the kite to the people if that is the shot you want.

4. FLY AT RISKY TIMES: Never fly into an urban environment during times of day when thermals are most active. For me photographically I prefer early and late light anyway, which are times of day when the sun is not producing a lot of nasty thermals. In the Urban Environ strong sun on blacktop parking lots, roofs, and streets, tends to boil up some active thermals that are difficult to control the kite in. Selecting cooler days and moderate wind speeds, along with early morning or late afternoon sun will minimize the problem of thermals.

D O

1. CHECK YOUR KIT: Take time to pre-flight all your equipment, double-check all kite and rig connections. Have a routine just like an airline pilot goes through before a flight and never neglect or minimize its importance. You must be willing to abort your KAP attempt if anything is out of order. An equipment failure can be very dangerous to someone no matter where it happens.

2. KNOW YOUR SAFE LAUNCH /RECOVERY SITE : Launch your kite in a safe, comfortable area that is accessible to your intended target. Let the kite fly for at least 5-10 minutes before connecting the camera rig to be sure that the wind is steady and reliable. Make sure that your kite is up to a height well above buildings in the area that may cause wind turbulence. With the camera on the line but at your hand you can walk into the target site.

3. P LAN the route of this journey so that you are walking down wind. Walking downwind keeps the kite out ahead of you and everything you need to worry about is in front of you and easy to see. If the wind drops or you find turbulence and become uncomfortable you can simply turn around and go back up wind to the safety of your launch site. Be very careful walking upwind with your kite to a target. If the wind begins to lessen you may be unable to walk back downwind to your launch site and you may be left with no choice but to land your kite where you are.

Conclusion
I am in no way advocating that you get your kites and head to the city to try flying in the heart of downtown. I am only saying that it can be done. The risks can be managed and minimized so that it is not all that different than flying in other locations. The most important aspect of KAP in the urban environ is the flying skill and focus of the operator. That skill combined with preparation and planning can mean that you can work your way into what seems to be kite unfriendly locations. The key to your success and safety will fall squarely on your ability to keep an unbroken focus on the task of KAP. If you are so nervous that you are uncomfortable or shaking, if you are unable to deal with all the aspects of the kite, camera, and interested onlookers, then it is not an environment to mess with. It is critical to be able to be in control, relaxed, and maintain mental focus.

When we expose our minds to what we perceive as great risk; running a red light, bungee jumping, standing before a charging rhino, KAPing in an urban environment, we need to train our mind to stay focused or bad things can happen and we can become helpless to stop them. Practice and repetition is how we become comfortable with all the inputs that KAP offers. We can progress from easy sites to KAP to more challenging ones, and we are able then to stay relaxed, focused, and comfortable performing at a high level in areas that might seem to add to the risk.

KITES & OTHER AIRCRAFT

When you are flying your kite you are sharing airspace with others: the rules are simple- you may not exceed a height of 200feet (60m) without express permission to do so. (See Appendix 1) In practice knowing the height of the kite is tricky and the variation in wind-speed can easily push you over the limit or, in some cases render the photographic objective unachievable.

Information on air-traffic

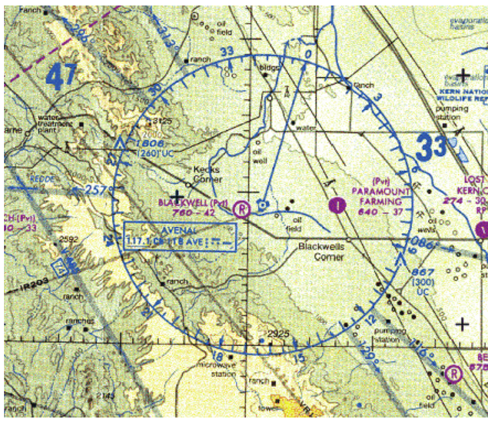
If you are going to be flying at or near the 60m limit it's worth getting to know where low-flying aircraft are going to be and just what height they will operate at. The Civil Aviation Authority (CAA) and the National Air Traffic Service (NATS) supply regular bulletins and publish charts showing obstructions to air-traffic. The 'rules of the air' are based on separation by a safe height between aircraft according to the direction of travel and a minimum flying height of 2000' except for aircraft in transition (approach, take off and landing), military and emergency aircraft.

Key Acronyms

VFR: Visual Flight Rules

A set of regulations which allow a pilot to operate an aircraft in weather conditions clear enough to allow the pilot to see where the aircraft is going. Specifically, the weather must be better than Basic VFR Weather Minimums, as specified in the rules of the relevant aviation authority (the FAA in the USA). If the weather is worse than VFR minimums, pilots are required to use Instrument Flight Rules (IFR).

VOR: VHF Omni-directional Radio Range



A type of radio navigation system for aircraft. A VOR ground station broadcasts a VHF radio composite signal including the station's identifier in Morse code (and sometimes a voice identifier), and data that allows the airborne receiving equipment to derive a magnetic bearing from the station to the aircraft. The VOR sweep sector is marked on the air navigation chart and is a good indication of where not to fly a kite at any height: in this sector aircraft will be in transition.

NOTAM: Notice To Airmen

NOTAMs are created and transmitted by government agencies under guidelines specified by Annex 15: Aeronautical Information Services of the Convention on International Civil Aviation. A NOTAM is filed with an aviation authority to alert aircraft pilots of any hazards en route or at a specific location. The authority in turn provides a means of disseminating relevant NOTAMs to pilots. If you intend to fly above 200' and permission is granted the CAA will post a NOTAM for a fixed period.

ATC Air Traffic Control

Contacting ATC should not be necessary unless you are responsible for a runaway kite in a transition zone!

CONCLUSION

From the experience gained between February 2009 and December 2009 it can be demonstrated with the example imagery in this report that KAP is a viable method of raising the camera for a variety of heritage record photographs.

The reliability and repeatability of KAP is different to other methods of raising the camera such as PAP, UAV or balloon but the cost, deployment speed, height, and duration of capture are all superior when conditions are right.

The positioning of the camera is, depending on the access to the subject, less precise than other methods but the resolution of a wide-angle equipped micro 4/3rds camera with a video downlink ameliorates this.

KAP is one of a group of techniques that should be used together to gain an optimum photo record of heritage assets, its application should be actively considered for low level oblique image capture which is complimentary to standard ground based and aerial cover. Vertical image cover by KAP is possible and, where achieved, (e.g. Warham Camp) the low flying height generates rich records.

This report gives an introduction to KAP. It is not comprehensive and the following topics should be considered as an important part of an overview of the technique

- High altitude (300m AGL) KAP (with CAA approval)
- Use of delta kites at low and high wind speeds- adaptation of kite fishing technique
- Use of sport (surf/boarding) kites and their adaptation for KAP
- Photo-cover metrics
- 360 panoramic capture by AuRiCo
- Image processing for montage of multi-perspective imagery
- Stereo capture
- Parallel performance with other UAV, PAP methods
- Review of archaeological KAP applications
- Certification and training in kite handling at kite sport schools
- Camera customisation
- Orthophoto integration of KAP imagery
- Habitat monitoring

I would like to thank English Heritage's Metric Survey Team for the privilege of conducting this work as a part of the Digital Recording Strategy; 'Raising the Camera' project.

Bill Blake
http://www.bill-blake.co.uk

15/12/10

Elveden War Memorial , Elveden Suffolk.

Extract from 12Mpixel image taken from a tethered kite at 45m AGL.

This page and preceding:: KAP imagery of ***Landgurd Fort Felixstowe, Suffolk*** *captured with a 12Mpixel camera in 12-15 mph wind.*

A 2 man team was able to direct the camera to cover the desired aspects of the monument. One operator controls the kite whist the other the camera by both radio control, video down link and direction of movement of the kite.

The low level stand off has recorded the condition of the upper surfaces of the monument as well as the movement of rainwater ponding.

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July 2007

Appendix 1

CIVIL AVIATION AUTHORITY **Air Navigation Order 2005**

KITES – AERIAL PHOTOGRAPHY
APPLICATION FOR PERMISSION TO FLY:
Above 60 metres / Above 30 metres within an Aerodrome Traffic Zone

28 days notice MUST be given of the event

If you require assistance with the completion of this form, please telephone 020 7453 6585

Completed forms should be sent to:

Airspace Utilisation Section,
Directorate of Airspace Policy,
Civil Aviation Authority,
K702,
CAA House,
45-59 Kingsway,
London,
WC2B 6TE. **Fax: 020 7453 6593. E-mail: ausops@dap.caa.co.uk**

Event...

Kite Operator...

Location of flight:

IMPORTANT: Attach a copy extract of 1:50,000 Landranger Ordnance Survey Map showing the site **CLEARLY** marked

Please do NOT use either A-Z or Road Atlas maps

Ordnance Survey Grid Ref: Map No.........Grid Letters.........Easting(3fig)............Northing(3fig)..

FULL postal address of site...

Contact telephone number at site (if available)...

Date/s of flight/s................................ Daily Period (in local time) From......................... To..

Height (in feet) above ground level of kite/s..

Type of photography, e.g. thermography, infra-red, normal…………………………………………………………………………………………….

Kite lighting, if flying during hours of darkness (the period from half an hour after sunset until half an hour before Sunrise):………………………………

Has the landowner's permission been obtained? Yes / No *

Have the Police been consulted? Yes / No *

FULL postal address of Police station consulted...

....

* Delete as applicable

DECLARATION

I declare that I have checked the above information and that, to the best of my knowledge, it is correct; and that I am aware of my obligations under the Air Navigation Order 2005 as the operator of kite/s.

Signature of applicant...

Date...

Name (BLOCK CAPITALS) and

status...

Address...

Tel.. Fax.....................................E-Mail...

Appendix 2

Kite Aerial Photography and UK Law by David Mitchell
http://www.zenoshrdlu.com/kapstuff/KAPUKLaw.html

This document provides references to some primary documents that define the legal framework within which Kite Aerial Photography operates in the UK. It may be useful in answering such questions as:

is a kite legally an aircraft?
how high can I fly my kite/rig combination?
what R/C frequency band(s) can I use?

One key piece of UK legislation is the **Air Navigation Order 2000** (otherwise known as Statutory Instrument 2000/1562). It contains three key statements.
First, it contains a table (Schedule 2, Part A) that classifies aircraft into categories as follows:

Lighter than air aircraft	*Non-power driven*	*Free Balloon*
		Captive Balloon
	Power driven	*Airship*
Heavier than air aircraft	*Non-power driven*	*Glider*
		Kite
	Power Driven (flying machines)	*Aeroplane*
		Landplane
		Seaplane
		Amphibian
		Self-launching Motor Glider
		Powered Lift (Tilt Rotor)
		Rotorcraft
		Helicopter
		Gyroplane

This makes it clear that a kite is an aircraft (heavier-than-air, non-power-driven) as far as UK legislation is concerned. The second important statement is in article 86 which contains rules for Balloons, kites, airships, gliders and parascending parachutes. Paragraph 2b (v) states: 86.2b (v) "a kite shall not be flown at a height of more than 60 metres above ground level" subject to the proviso "without the permission in writing of the CAA and in accordance with any conditions subject to which that permission may have been granted."

Although kites weighing less than 2kg were exempted from this rule in earlier ANO's, they no longer are because the third statement, in article 132, states: 132. The provisions of this Order other than articles 58, 64, 85(1), 86, 87, 118(1)(b), 129(1), (2) and (5) shall not apply to or in relation to: (a) any small balloon; (b) any kite weighing not more than 2 kg; (c) any small aircraft; or (d) any parachute, including a parascending parachute

Since article 86 does apply, kites in the UK are restricted to flying below 60 metres (around 196 feet). In fact the restriction is 30 metres within the aerodrome traffic zone of a notified aerodrome during the notified operating hours of that aerodrome (article 86.2b (iv).
Getting permission from the CAA is not an impossible task however. Permission has to be sought for each site, giving at least 28 days notice, but permission can be granted for periods up to six months.

You can ignore the other restrictions unless you are in the habit of dropping articles from your rig (articles 58 and 87) or endangering the safety of persons or property (article 64) or are subject to a ban on flying by the Secretary of State (articles 85 and 118). Note that kites weighing less than 2kg are exempt from article 84. This refers to another Statutory Instrument, the Rules of the Air (SI 1996/1393).

Article 104 imposes restrictions on aerial photography on aircraft which are registered outside the UK. By implication, the order imposes no such restrictions on aerial photography on aircraft registered within the UK.
The Civil Aviation Authority, which is empowered to regulate all civil flying activities over the United Kingdom, provides a Guide to Safe Flying for Model Aircraft in document CAP 658 which lays down guidelines for where, when and how model aircraft may be flown. Interestingly, it turns out that if your model weighs more than 7Kg (15 lbs or so) then you must ask the CAA for permission to do aerial work - that is receive remuneration for flying activities. The rule specifically includes aerial photography.
However this document specifically excludes balloons and kites from the rules it lays down (see Definition of a Small Aircraft - paragraph 1 of Chapter 2).

Statutory Instrument 1987 No. 776, the Wireless Telegraphy (Exemption) (Amendment) (Model Control Apparatus) Regulations 1987, is the piece of legislation defining the various frequency bands allocated for "model control" in the UK. It defines four frequency bands for "model control" as follows:

1	*26.96 MHz to 27.28 MHz*
2	*458.5 MHz to 459.5 MHz*
3	*34.995 MHz to 35.255 MHz*
4	*40.665 MHz to 40.955 MHz*

Bands 1 (27MHz) and 2 (459MHz) are defined for general "model control".
Band 3 (35MHz) is restricted to: model control equipment which is capable of being used solely for the purpose of controlling the movement of model aircraft
Band 4 (40MHz) is restricted to: model control equipment which is capable of being used solely for the purpose of controlling the movement of models on land or on water surface, and whose design employs exclusively the use of frequency modulation techniques

In addition the 433MHz band has been allocated for download telemetry from model aircraft.
This Statutory Instrument does not define 'model aircraft'. However it is an amendment to the earlier Wireless Telegraphy (Exemption) Regulations 1980 (S.I. 1980/1848), which defines "model control equipment" as: wireless telegraphy apparatus designed or adapted for the purpose of controlling (otherwise than by means of telephony) the movement of a model vehicle, vessel or aircraft or a model of any other type by means of the emission of electro-magnetic energy from that apparatus and the reception of such energy by receiving apparatus in the model It's clear that the equipment used for R/C KAPping is designed for the purpose of controlling ... the movement of ... , though it might be a stretch to describe a KAP cradle as a model.

OFCOM (which replaced the earlier Radiocommunications Agency as the appropriate regulatory authority), issues Information Sheets on these matters. RA 60 covers "radio-controlled models" and provides a useful summary.

The documents mentioned above are all currently available on-line:
Air Navigation Order 2000 (SI 2000/1562)

CAA Guide to Safe Flying for Model Aircraft (CAP 658) (A PDF Document)

Wireless Telegraphy (Exemption) (Amendment) (Model Control Apparatus) Regulations 1987 (SI 1987/776)

Wireless Telegraphy (Exemption) Regulations 1980 (SI 1980/1848). Note that this is not available from the HMSO website, but it is available from the Jersey (Channel Islands) legal site.

OFCOM RA 60

See also The UK Radio Control Council's website which has frequency tables for many countries, including the UK, most of Europe and the USA.

Appendix 3

Radio-Controlled Models

1. Introduction

This information sheet serves two purposes. Firstly, for those who are new to the use of radio for controlling models it answers the basic questions about the frequencies and technical restrictions that apply. Secondly, for existing users it explains the additional frequency bands that have been made available for radio controlled models because of interference problems in the 27 MHz bands.

2. What are radio-controlled models?

Radio controlled models are of two types - :

- those that operate on the ground or on water, known as "surface" models; and
- those that are airborne.

Typically, radio control is used for model cars, ships (including steam, motor vessels and yachts) and aircraft. Radio-controlled models are often entered into competition, and the frequencies that are now available will facilitate their operation in European competitions.

This information sheet is directed towards the serious use of radio-controlled models. Toy radio-controlled models tend to operate at 49 MHz, where a small band exists for general-purpose low-power radio devices. Technical details of this band can be obtained from the Radiocommunications Agency - see Section 10.

3. Do I need a licence to operate model control equipment?

No. Model control equipment was exempted from the licensing requirements of the Wireless Telegraphy Act 1949 on 11 January 1981. The current regulations are contained in the Wireless Telegraphy (Exemption) Regulations 2003 (S.I. 2003 No. 74). Copies are available from any Stationery Office Bookshop.

Although licences are not required, equipment must still meet the technical conditions set out in the Regulations - see Section 6.

4. What frequencies are available?

The frequency bands available for the use of radio controlled models are shown below, with the maximum effective radiated power output of the transmitter measured in milliwatts.

Frequency (MHz)	Use	Effective radiated power (mW)
26.96 to 27.28	General	100
34.945 to 35.305	Air	100
40.66 to 41.00	Surface	100
458.5 to 459.5	General	100

The 26/27 MHz band is also allocated for Citizens' Band (CB) radio and for low-power telemetry and telecommand devices, as well as for model control - see Section 7.

The 458/459 MHz band is also allocated to general telemetry and telecommand devices between 458.5 - and 458.95 MHz, and to specialised telemetry between 458.95 - and 459.1 MHz. While the potential for mutual interference is minimal, model controllers should avoid the specialised telemetry part of this band.

The use of the different bands is important. The 40 MHz band is dedicated solely to surface modelling. It consists of 34 channels with a 10 kHz channel spacing; the centre frequency of the first channel is 40.665 MHz. The 35 MHz is dedicated solely to aeronautical modelling. It consists of 36 channels with a 10 kHz channel spacing; the centre frequency of the first channel is 34.950 MHz.

5. Can I transmit data from the model?

Yes. Telemetry can be transmitted from general, surface or air models back to the controller. The band is 433.050 to 434.790 MHz; the maximum channel spacing is 25 kHz and the maximum radiated power is 10 mW. Please note that the band is not exclusive to model controllers - it is shared with other users, who are permitted to radiate relatively higher powers, so you must take care when selecting a channel for use in a particular locality.

6. What technical conditions do I have to observe?

Firstly, all model control equipment must operate within the frequency bands shown above. Secondly, the effective radiated power of the equipment must not exceed that shown alongside the frequency band in the table above.

These technical conditions are laid down in the Regulations, which have exempted model control from licensing. The Regulations also contain other conditions; most importantly, model control equipment must not cause undue interference to other wireless telegraphy equipment.

In addition, the organising bodies for the various sections of the model control hobby have established Codes of Practice and preferred band plans, designed to ensure the successful operation of models. Details are available from the UK Radio Control Council - see Section 9. In particular, to ensure safe operation it is necessary that no two modellers in the same area try to use the same frequency at the same time.

7. Interference in the 27 MHz band?

The 26.965 to 27.405 MHz band is allocated for CB radio, in accordance with a Recommendation put forward by the Conference of European Posts and Telecommunications Administrations (CEPT). The 27 MHz band is still available for model control but interference may be suffered from the other users of the band.

Within the model control band, there are five 10 kHz-wide channels that are used by low-power telemetry and telecommand devices but are not operational channels for CB. These have centre frequencies of 26.995, 27.045, 27.095, 27.145 and 27.195 MHz. While these channels may also suffer from interference, they should provide the best operating frequencies for model control within the new 27 MHz band.

In view of the problems associated with the 27 MHz band, frequency bands were made available at 35 and 40 MHz for model control. Just as CEPT CB was introduced on new frequencies to allow European harmonisation, the release of the frequencies at 35 and 40 MHz has brought the UK into line with other European administrations.

8. Is 35 MHz just for aeronautical modelling?

Yes. The Exemption Regulations make it clear that the channels at 35 MHz are solely for aeronautical modelling. Surface modellers must not use these channels. Similarly, aeronautical modellers must not use the allocation at 40 MHz, as this is reserved for surface modelling.

9. What is the UK Radio Control Council?

The UKRCC consists of representatives of all aspects of the model control hobby. It meets the Agency from time-to-time to discuss model control interests. It was from consultations in this forum that new frequencies were made available. Further information about the UKRCC may be obtained from:

Mr. D. W. McQue
The Secretary
UK Radio Control Council
6 Laburnum Grove
Bletchley
Milton Keynes MK2 2JW.

Tel: 01908 378277

E-mail: g4nju@aol.com
W ebsite: www.ukrcc.org

10. Further information

Enquiries about information given in this information sheet should be addressed to:

Science and Technology Unit
Radiocommunications Agency
Wyndham House
189 Marsh Wall
London E14 9SX

Tel: 020 7211 0153

Fax: 020 7211 0162

RA 60 (Rev 8)
February 2003