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POSSIBILITIES AND LIMITATIONS OF UNMANNED BALLOONS

AND

AIRSHIPS IN ARCHAEOLOGICAL WORK

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The range of applications and usability of unmanned,remote-controlled balloons and airships as camera carriers has been put to the test in various archaeological research projects. The advantages of the aerodynamically shaped airship have also been proved; for use in the third world a hot-air system is also more fitting, because there is little guarantee that inert gases such as hydrogen or helium are obtainable. Apart from this the hot-air system has proved itself to be robust in its construction and simple in its operation and maintenance. Enough has been said in other articles about the state of technology. The aim of this paper is to explain the range of applications and limitations in the use of an unmanned, remote-controlled, aerostatic airborne system (balloon or airship):

- size of the area to be documented
- climate, wind and weather
- limitations of construction in relation to profitability

THE CONTRIBUTION OF AERIAL PHOTOGRAPHY TO ARCHAEOLOGY

The development of lighter and handier cameras in the late 19th century led to the first attempts being made to photograph archaeological excavations from manned balloons or model kites (Dewel, 1972).

It was not until the invention of the aeroplane, however, and its being equipped with a camera for military reconnaissance that the systematic documentation of objects best visible from the air became possible. Thus in 1916 German pilots were able to make a photographic record of the state of ancient urban sites in Palestine and Syria on behalf of the German-Turkish Office for Architectural Preservation. Similar developments were also taking place on the English and French fronts.

Working in Wessex in the 1920's, the Englishman O.G.S. Crawford opened up a completely new field of application for the new technology - the prospection of archaeological remains buried under the surface. Experience taught him that every architectural fragment hidden just under the earth's surface causes a disturbance in the fabric of the soil which is only visible from the air.

According to the nature of the soil disturbance the archaeological sites thus discovered have been classed into the following:

SHADOW SITES betray their existence by casting characteristic shadows on the surrounding countryside when the sun is very low in the sky.
CROP SITES show up as areas of stunted corn growth due to the structural remains underneath, or of denser growth above filled-in ditches rich in organic waste.
SOIL MARKS are simply discolorations in the soil caused by subterranean remains.

Under suitable photographic conditions - position of the sun, season, climate - these soil disturbances can reveal an astonishingly clear picture of buried monuments (Dewel, 1972).

In the 1950's and 60's this prospection method was utilized to great effect by the Rheinische Landermuseum in Bonn under the direction of I. Scollar. In Northrhine-Westphalia alone, several thousand prehistoric and ancient historic settlement sites were discoverd, particularly of the Roman period. Before a geometric evaluation of the photographs can be carried out, the distortion caused by the extremely oblique photographic angle has to be rectified by means of a digital photographic processing method. The rectified pictures are then entered accordingly on the German Base Map to the scale of 1:5,000 (Robinson, 1982; Scollar, 1965).

So far, however, air photography has not succeeded in replacing the land surveying of archaeological excavations by photogrammetric evaluation. Apart from the cost and organisation involved, this is mainly due to the impossibility of taking large-scale pictures (mb > 1:1000) from an aeroplane, restricted as this method is by minimum flight altitudes and speeds.

DIFFERENCES IN THE SYSTEM

Normal balloons always have a right to a place alongside the aerodynamically shaped airships, even though their suitability for the prodution of pictures which can be used for measuring purposes is limited because of their much greater tendency to sway in high winds. The advantage of the "Normal" balloon shape over the airship is its simple manufacture. When only survey photos of an excavation area are desired, and these pictures are not to be analysed for measuring purposes, then such balloons show definite advantages. Because the shape of the balloon has a much smaller surface area than that of an equivalent, in relation to its volume airship, then the amount of material and hours required for its construction are greatly reduced, a ratio of approx. - 3. A normal balloon envelope (hot-air) with an empty payload of 10 kg and a volume of about 100 m^3 would cost about 3000 German Marks. Approx. the same amount must be paid for the burner, remote-control unit and camera moutnting. For an airship with the same payload one would pay about 15,000 Marks.

Through experience with these types of balloons and airships we estimate 300 hours to be the approximate service life of the balloon envelope; 400 hours have been achieved by manned balloons, but under easier conditions. A new envelope is required in all cases after this amount of time; the rest of the equipment should at least receive a general overhaul (remote-control unit, burner, camera mounting etc.).

This list gives a simplified estimate of the depreciation of a balloon or airship. A further 10 Marks for each operational hour must be included for fuel. We were able to produce 6 - 8 pictures suitable for measuring purposes in each hour in Pakistan: simple survey photos which required no positioning or alignment of the camera took only half the time.

LIMITATIONS

Through experience with difference systems, certain differment limitations can be noted.

SIZE OF THE AREA TO BE DOCUMENTED

An "aerostatic" airborne system is suitable for relatively small areas because it can record even the smallest of details. Thus there is no competition from conventional surface aircraft, because the latter can only offer cheap "documentation costs per hectar" for larger areas, and cannot pick out exact details (cf. Wanzke, 1983; Heckes 1983).

It is often the case that such a balloon or airship system is the only possibility for aerial photograph documentation, so that a higher interpretation expenditure per hectare, because of the large amount of pictures, seems justifiable (cf Wanzke, Part I).

Any solution to reduce the amount of pictures to be analysed through the use of large format cameras must be viewed critically by the balloon/airship constructor and more will be said about this problem later.

CLIMATE, WIND AND WEATHER

When the decision has been made to use a balloon or airship for aerial photography in the documentation of an excavation site, then the climatic conditions of the area must be comprehensively studied, while the success of the operation depends upon favourable conditions especially wind speed.

The airship used by us in Pakistan proved to be operational for measuring work in winds of 8 - 10 knots. For survey photos (requiring less exact positioning) the airship could be used in wind speeds of up to 10 - 12 knots.

The appropriate information about temperature, airpressure and wind speed, in daily, monthly and yearly form, can be obtained from airports or meteorological stations in the respective country.

When the field work is to be carried out over a period of weeks or months, then one can usually count on enough possibilities for the airship's operation. However, if the work is to be carried out "to order" then this can be disrupted by unfavourable climatic conditions.

GREATER PAYLOADS - LARGE FORMAT CAMERAS

It is, in principle, conceivable to produce balloons or airships with greater payloads for the transport of cameras with a larger format than the previously used Rolleiflex 6 x 6.

The wish to reduce photo and analysis time is understandable, but from the point of view of the constructor, the following factors are against this:

A simple increase in the volume does not lead to a very great increase in the construction and fuel costs of such a system, in any case propritionally lower than the volumal increase and the greater payload. However, an enlargement does inevitably lead to an increase in operational personel. While our airship in Pakistan could be safely controlled by 3 - 4 people, an increase in volume and empty payload, with the thus increased air-resistance of the whole machine, leads to a steady increase in the amount of personel required.

Each member of the ground team can hold no more than 30 kg traction for any length of time, especially when the adhesion and stability are lowered in areas of rubble and debris. One solution could be improvements in the balloon or airship construction, with the aim of improving the positional exactness and reducing the amount of time needed for photographic work. Possible improvements have already been considered (Busemeyer, 1983), such as the automatic alignment of the camera by gyroscope or electronic compass. The construction of movable steering elevators on the airship would most probably reduce the amount of time required per aerial photograph, but on the other hand it would increase the construction and production costs, and almost certainly lead to complications in the system as a whole. A consequence thereof is that the machinery would require more maintenance, and in some cases repairs could not be carried out on site with the equipment available, which never caused any problems with our simpler system in Pakistan. The constructor has the problem with each improvement in detail that this should not lead to more complications, and the problem that the airship can only be manned by a highly qualified team after the improvements.

SUMMARY AND FUTURE PROSPECTS

There are two different approaches to aerial photography work:

- a simple, relatively small system with a payload only a few kilograms and corresponding low construction and operation costs, which can be easily operated and maintained by trained assistants and one "qualified" pilot. This system would be equipped solely with a miniature of 35 mm camera for survey photos only, and in exceptional cases photos for measuring purposes. The operation should be able to be carried out fully by a Research Project Team.

- a comparatively complicated system with automatic positioning and corresponding greater expenses, to be used solely for measuring photos, which can later be analysed. The operational costs would certainly be in the region of several hundred Marks per day, as a result of the high production costs and allowing for the fact that at least one qualified person, with the theoretical and practical knowledge of a hot-air balloon pilot, would be needed to control the machine (and would have to be paid for this). Only exceptional archaeological research projects would include such qualified personel.

It is hard to put payload limitations described here into concrete figures, the limits of such being clearly rather vague. Given the present state of balloon and airship technology, I would estimate the payload limit to be 30 kg, greater payloads and the associated costs would very probably exceed the budget of a "standard research project", these costs being close to those of a conventional manned aerial photography system. In an attempt to better define the limitations, we are at the moment working on a larger model of the type used by us in Pakistan, with a planned volume of 250 m^3 (previously 145 m^3) and payload of 30 kg, to be used with either several camera systems, or one, large-format camera.

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