PROCEEDINGS OF THE INSTITUTE OF GEODESY AND CARTOGRAPHY
Volume XXIX, No. 2, 1982

ANDRZEJ CIOŁKOSZ
ANDRZEJ NOWOSIELSKI

Photographs taken from a balloon and a powered hang glider

A b s t r a c t. Endeavour after reducing costs of taking aerial photographs of agricultural test sides the Polish Remote Sensing Centre has started seeking for another platform for cameras. A tethered balloon equipped with metric Hasselblad MK-70 and multiband NAC MB-470 cameras has been used for those purposes.

Owing to the fact of some disadvantages of balloon a new platform — powered hang glider has been designed and constructed. In the paper authors discuss their experiences in taking aerial photographs from these platforms.

1. Introduction

In investigations of natural phenomena, carried out by means of remote sensing methods, it often becomes necessary to take a series of photographs over small areas from a considerably low altitude. The utilization of photogrammetric aeroplanes for this reason is above all very expensive and, besides, it is very difficult to organize a flight at determined dates and weather conditions. It is even an undertaking impossible to perform, especially in case of taking photographs every few hours and when the photographed area is located far away from the airport.

Meanwhile, the Polish Remote Sensing Centre (OPOLiS), in its investigations particularly in the field of applying remote sensing in agriculture, has been faced many times with the necessity of taking photographs of test sides, of several square metres, in precisely determined vegetation phase and conditions of the Sun illumination. At the beginning for taking such photographs a helicopter was applied, then lightweight aeroplanes took its place. Due to the rise of renting costs of a plane, other solutions were necessary.

2. Balloon as a platform for aerial camera

In this situation there was a return to the beginning of the era of photographs taken from the air, namely from a tethered balloon. This time however, instead of a big balloon with a nacelle for the photographer,

a small balloon, normally used for meteorological investigations of atmospheric probing was applied. A balloon of 15 m^3 volume produced by the French Delacoste firm was chosen. This was dictated, on the one hand by the necessity of using helium not hydrogen, which eliminated the danger of explosion and, by limitations in the amount of the used helium, on the other.

The balloon envelope is made of a specially light and strong film. Inside the envelope a neoprene, tensile inset is placed which when filled with gas expands enabling the envelope to assume the appropriate shape. Vertical and horizontal stabilizers facilitate the aerostat to take the position with the smallest section perpendicularly to the direction of the wind.

Under the balloon, on three lifting lines a special gimbal was suspended onto which a photographic camera was hung. To the gimbal also attached were three approx. 160 meters long tether lines which allowed to raise the balloon with the camera to the altitude of about 150 metres. These three tether lines were used to direct the balloon over the determined area.

The photographic camera was fixed to the frame by means of a special hanger, constructed at the Mechanical Department of the Institute of Geodesy and Cartography (IGiK). Its essential part was a system of two pairs of pneumatic shock absorbers which in effect of inclination caused

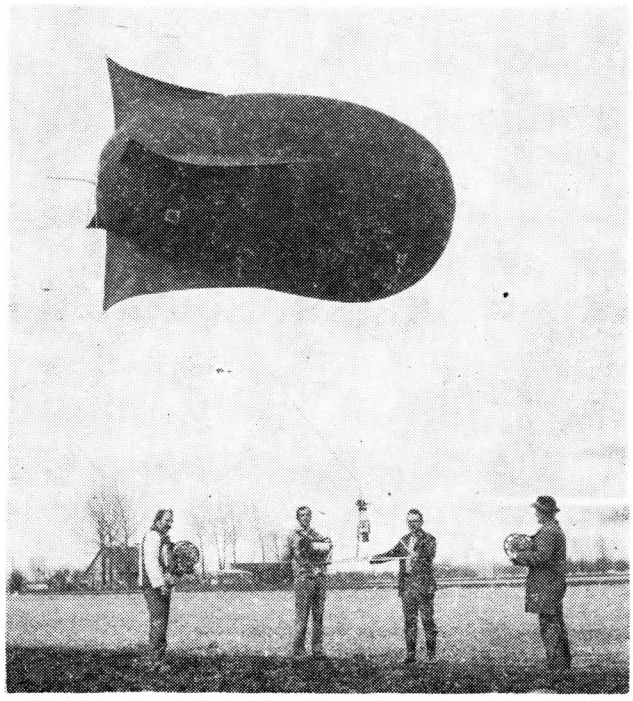

Fig 1 Balloon of French Delacoste firm prepared to arising with a photographic camera

by the wind enabled quick return of the camera to the vertical position of the opical axis. Either the Hasselblad MK-70 metric camera, or the Japanese NAC MB-470 multispectral camera could be suspended to the gimbal. Both cameras were additionally equipped with a motor and radio controlled device for controlling the shutter and moving the film.

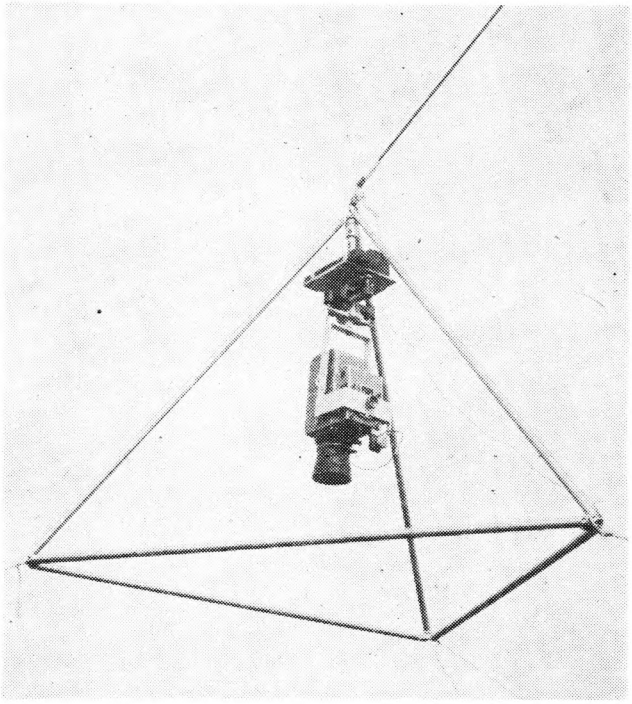

Fig 2 The radio-controlled Hasselblad MK 70 metric camera hanging in its gimbal

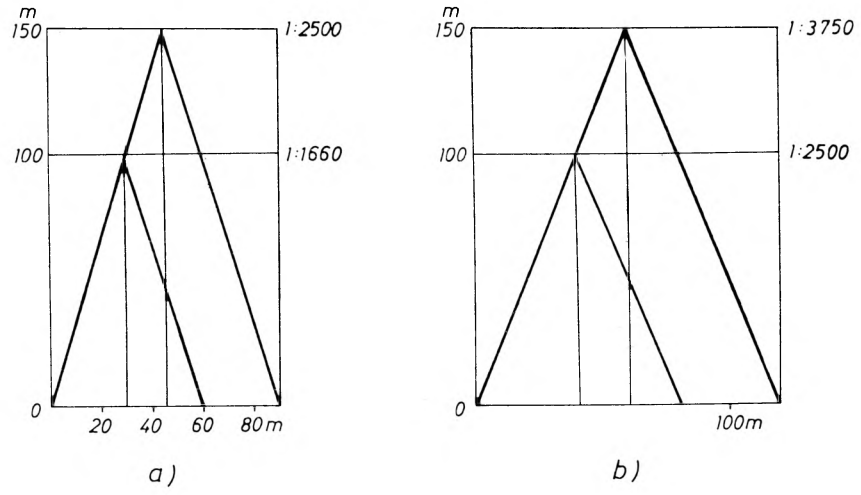

Fig. 3. Interdependence of a flying height, a scale of photograph and a side of photographed area for Hasselblad MK 70 camera (a) and multiband NAC MB 470 camera (b)

In order to obtain photographs in the required scale, a camera must be raised over the photographed area, depending on the focal length of the lens. In case of the Hasselblad MK-70 camera, the focal length was 60 mm, while the NAC MB-470 multispectral camera was equipped with lenses of 40 mm focal length. Fig. 3 shows relations for both cameras between the altitude of taking photographs, scale of photographs and size of photographed area.

The displacement of the balloon turned out to be insufficient in relation to the weight of the camera with the gimbal and the tether lines, and for this reason even in the best weather conditions it did not attain the expected altitude of over 150 metres. The altitude of the balloon, and thus the approximate scale of photographs, was estimated on the basis of the length of the tether lines, uncoiled from a drum and the distance between their tether points according to the following relation:

$$h = \sqrt{l^2 - \frac{a^2}{4}}$$

where

l — the length of the uncoiled line,

a — the distance between tether points, equal the width of the photographed area.

However, considering the fact, that even the wind of the speed slightyl over 2 m/sec caused the knocking down of the balloon, it did not attain the altitude shown by the uncoiled lines and it was decided, that in order to exactly determine the scale of photographs special marks — black crosses on white background, were placed on the photographed area. The distances between them were measured directly in the field. These marks played the role of ground control points.

Practically, during the experiments, the altitude of 100 metres was attained which allowed to take metric photographs at the scale of 1 : 1600 and multispectral photographs at the scale of 1 : 2500. The size of the measuring photographs at this scale allowed to project on one image 90×90 metres, i.e., the surface of 0,81 hectare. On multispectral photographs — 24×24 mm size, the area of 60×60 metres was projected, i.e., the surface of 0,36 hectare.

The area was prepared earlier for taking balloon photographs. Considering the size and scale of the photographs, spatial locations for the balloon were determined, which should be occupied by it at the moment of taking the photographs. For assuring that the balloon would take those locations, certain points were determined in the area for the lines holding the balloon. In this way, facilitated were the taking of not only directed photographs, but also of a series of photographs with an advanced determined longitudinal overlap.

3. Taking air photographs from powered hang glider

In spite of the easiness in operating the balloon when taking photographs from low altitudes and low costs of taking these photographs already after the first experiments it turned out, that this way of transporting the camera must be abandoned. The balloon's displacement was too low in comparison to the weight of risen devices and tether lines, and thus it was not able to surmount even a weak wind.

In this situation it was decided to utilize the experiences of specialists from the Czechoslovakian Academy of Sciences and to construct a remotely controlled powered hang glider, capable of carrying a small format camera to the altitude of several hundred metres.

The powered hang glider, as the carrier of the camera, must meet three basic assumptions, which were considered in the design process.

It should, first of all, be very easy to operate, it should have a small forward speed of flight and it should be able to fly even during strong winds.

Considering the above mentioned assumptions, an appropriate flying model was designed. It is a hang glider equipped with a motor propulsion. The wing, of considerably big size (of surface 1.6 m^2) ensures the car-

Fig. 4. Powered hang glider and NAC MB 470 multiband camera

rying power, which is sufficient for raising the camera. The wing of the Rogallo type is mounted about 40 cm over the fuselage at the angle of +12.5 degrees, which influences the stabilization of flight. The wing is constructed of duralumin tubes of thin walls. The wing construction is connected with hinges, so it can be folded during transportation. The wing is covered with the „dacron" parachute film produced in the Federal Republic of Germany.

The fuselage of the powered hang glider was constructed of balsa wood boards. The inside floor divides the fuselage into two levels. In the upper one there are controlling devices, consisting of a radio receiver and servomechanisms for controlling the direction and the depth of the flight as well as controlling the rotation of the motor. These are devices of the Varioprop — 12 type produced by the Grundig firm. In this level, there is also a fuel tank of 300 cm^3 capacity. In the lower level of the fuselage there is a bed for installing a camera and servomechanisms for controlling the work of the camera.

The powered hang glider is driven by the Italian „Super Tigre G71" I.C. engine with a hot-bulb ignition. This engine is equipped with a carburettor, allowing flexible control of the engine's revolutions in the range of 2500—14000 revolutions per minute. On the engine's shaft there is an airscrew of 300 mm diameter. The engine's thrust force is about 4 — 4.5 kG.

The control of the model is performed by means of the 7-band Grundig transmitter.

In the rear of the powered hang glider there is the tail plane consisting of the elevator and rudder.

The powered hang glider is characterized by a considerably small forward speed, 30 km/h, during windless weather. The hang glider is receptive to the attacks of wind, but, thanks to small speeds, its inclinations can be easily controlled and it can be lead along the determined route. From experiments it results that the powered hang glider can be used only in conditions when the wind's speed does not exceed 8 m/sec.

Of crucial advantage is the fact that the powered hang glider can be used at any unrestricted time. This device does not require special conditions for taking-off and needs only several meters of flat area for the run. Of a certain limitation in applying the powered hang glider is its relatively short time of flying, about 15 minutes. However, this is a rather minor disadvantage, since only several minutes are necessary to prepare it again for the following flight.

The discussed powered hang glider was adjusted to work equipped with the Hasselblad MK-70, Hasselblad EL-500 and the multispectral NAC MB-70 cameras. However, only one camera can be mounted to the hang glider at a time.

4. Multiband camera NAC MB-470

So far the majority of photographs taken from a balloon as well as from a powered hang glider were done by means of a small format NAC MB-470 camera. It is a 4 lenses camera, which on one 55×55 mm picture gives four photographs, each of the size 24×24 mm. This camera is equipped with four filters: blue, green, red and infra-red. Photographs by this camera are taken on a film sensitive to broad spectrum range, which encompasses visible and near infra-red radiation. That is why lenses with filters transmitting visible radiation are additionally equipped with filters which stop infra-red radiation so that this spectrum range does not reach through the blue, green or red filters the light sensitive emulsion. The speed of each of the four lenses of the camera is $f/2.8$.

The camera is equipped with a rotary shutter allowing simultaneous exposure of the four photographs.

At the Institute of Geodesy and Cartography this camera was additionally equipped with a motor for controlling the shutter and the movement of the film. The diaphragm in various lenses is manually adjusted directly before the flight. Particular lenses are also manually focused. The exposure time is common for all four lenses. The camera has only two speeds of the shutter: 1/125 and 1/250. These are considerably long exposures, but when the hang glider flies at the speed about 30 km/h, the blur effect is 0.06 mm or 0.03 mm respectively, and thus is omitted. Under normal illumination conditions the 1/250 sec. exposure is applied in general. The obtained photographs are of good quality.

5. NAC Additive Color Viewer AC-70

The most frequently applied method of processing photographs taken by means of this camera is the creation of colour composites utilizing special projectors. The Japanese NAC Incorporated firm designed a device called the Additive Color Viewer AC-70 for elaborating photographs taken with the MB-470 camera. It is a projector facilitating simultaneous projection of the 4 photographs onto a common screen. The displayed photographs overlap one another. Depending on the filters used and the power of the light, from the same photographs many colour combinations can be obtained on the screen. This device was equipped with a special still camera stand for installation of still camera, taking photographs of colour images created on the slide viewer.

This colour slide viewer was modified at the Institute of Geodesy and Cartography so as to make colour positive prints directly from the screen. Instead of a lustreless screen a transparent one was applied for this reason. Additionally a grey filter was used in order to decrease the amount

of light passing through particular lenses, as well as a focal plane shutter was fitted in the colour slide viewer. In this way modified device, a required colour composite is created on the screen. Then the amount of light is decreased according to the needs of the exposure. This decrease cannot be performed by means of the manufactured built-in potentiometers, since in this case the light's colour temperature changes, which influences the colours of the photographic prints. A printing paper is placed onto the transparent screen which is then exposed by means of a built-in focal plane shutter. The contact photographs, 18×18 cm, in this way obtained, are of excellent quality characterized by good sharpness and the proper colour balance. These photographs are output materials for further visual photointerpretation.

The taking of aerial photographs from balloon and powered hang glider could only be accomplished with co-operation of various individuals. Amongs the many who were concerned the authors would like to express special gratefulness to: Mr. Z. Goljaszewski, Dr. A. Uhrynowski, Mr. J. Kosiński and Mr. W. Piotrowski.

Translation: Jacek Domański

АНДЖЕЙ ЦИОЛКОШ
АНДЖЕЙ НОВОСЕЛЬСКИ

АЭРОСНИМКИ ВЫПОЛНЕННЫЕ С АЭРОСТАТА И РАДИОУПРАВЛЯЕМОЙ МОДЕЛИ САМОЛЕТА

Резюме

Исследование явлений, происходящих на поверхности Земли, с помощью методов дистанционного зондирования неоднократно требует выполнения серии аэроснимков малых объектов со сравнительно небольшой высоты. Использование с той целью фотограмметрических самолётов является слишком дорогим, также и организация полётов в точно определенный срок и в соответствующих атмосферных условиях наталкивается на трудности.

В этой обстановке Центр обработки аэрокосмической информации, который многократно столкнулся с необходимостью фотографической регистрации тестовых полей для сельского хозяйства в точно определенных стадиях развития растений, решил для выполнения таких снимков применить привязной аэростат, как средство переноса фотографической камеры.

Используемый аэростат это аэростат французской фирмы Delacoste. К аэростату была подвешена рама в форме пирамиды, в вершине которой было прикреплено амортизированное ярмо с закрепленной камерой. К раме прикреплены дополнительно три каната, задачей которых было управление аэростатом над местом фотографирования, а также органичение поднятия аэростата на определенную высоту.

Поднятие аэростата над поверхностью территории определялось на основе

длины отмотанных якорных канатов, которые для этой цели были соответственно размечены.

Во время экспериментов была достигнута высота фотографирования порядка 100 м., что дало возможность выполнения съёмки в масштабе около 1 : 1 600 (камера Hasselblad MK-70) и многозональных снимков в масштабе около 1 : 2 500 (камера NAC MB-470). Обе примененные камеры обладают возможностью радиоуправления в области экспозиции и перемотки плёнки.

Аэростат как носитель камеры оказался слишком мало практичным, ибо был податливым на воздействие даже слабого ветра, а его подъёмная сила разрешала на поднятие камеры на высоту не больше, чем 100 м. В этой ситуации решено было использовать опыт Чехословацкой Академии Наук и сконструировать радиоуправляемую модель самолета, как устройство поднятия фотокамеры. Радиоуправляемая модель самолета обладает легкостью пилотажа и может стабильно двигаться по заданным маршрутам.

Радиоуправляемая модель самолета это модель моторного самолета с крылом типа Rogallo. Управляется она с земли приёмно-передаточным радиоустройством фирмы Grundig, в котором использовано управление пятью сервомеханизмами, а именно: руль направления и руль высоты, обороты двигателя, срабатывание затвора и перемотка плёнки в камере.

Модель самолета приспособлена для закрепления в её корпусе камер Hasselblad MK-70 и EL-500, а также многозональной камеры NAC MB-470.

Камера NAC MB-470 это камера с четырьмя объективами, снабженная фильтрами, пропускающими излучение в четырех спектральных диапазонах (синий, зелёный, красный и инфракрасный). Для составления синтезированных изображений из снимков, полученных с помощью упомянутой камеры, применяется чаще всего аддитивный проектор фирмы NAC Mini Viewer AC-70. В зависимости от примененных фильтров и используемой силы света на экране проектора можно получать разнообразные синтезированные изображения тех же самых снимков. Проектор модифицирован относительно фабричной версии и благодаря этому обладает возможностью регистрации синтезированных изображений непосредственно с экрана на цветную фотобумагу контактным способом. Такие снимки являются исходным материалом для визуальной интерпретации.

Перевод: Róża Tołstikowa

ANDRZEJ CIOŁKOSZ
ANDRZEJ NOWOSIELSKI

ZDJĘCIA FOTOGRAFICZNE WYKONYWANE Z BALONU I MOTOLOTNI

Streszczenie

Badanie zjawisk zachodzących na powierzchni Ziemi za pomocą metod teledetekcyjnych niejednokrotnie wymaga wykonania serii zdjęć lotniczych małych obiektów ze stosunkowo niedużej wysokości. Wykorzystywanie w tym celu samolotów fotogrametrycznych jest zbyt kosztowne, również i organizacja lotów w ściśle określonych terminach i warunkach atmosferycznych napotyka trudności.

W tej sytuacji Ośrodek Przetwarzania Obrazów Lotniczych i Satelitarnych, który wielokrotnie zetknął się z potrzebą fotograficznej rejestracji pól testowych dla rolnictwa w precyzyjnie określonych fazach rozwoju roślin, postanowił do wykonywania takich zdjęć zastosować balon na uwięzi, jako środek przenoszenia kamery fotograficznej.

Użyty balon to aerostat francuskiej firmy Delacoste. Do balonu podwieszono ramę w kształcie piramidy, u której wierzchołka umocowano amortyzowane jarzmo z zamontowaną kamerą. Do ramy umocowano dodatkowo trzy linki, które miały za zadanie sterowanie balonem nad miejscem fotografowania, jak również ograniczenie wyniesienia balonu na odpowiednią wysokość.

Wyniesienie balonu nad powierzchnię terenu określano na podstawie długości odwiniętych lin kotwiczących, które w tym celu zostały odpowiednio wyskalowane.

W czasie eksperymentów osiągnięto wysokość fotografowania rzędu 100 m, co umożliwiało wykonanie zdjęć pomiarowych w skali około 1 : 1600 (kamerą Hasselblad MK-70) i zdjęć wielospektralnych w skali około 1 : 2500 (kamerą NAC MB-470). Obie zastosowane kamery posiadają możliwość sterowania radiem w zakresie ekspozycji i przewijania filmu.

Balon jako nośnik kamery okazał się zbyt mało praktyczny, gdyż był podatny na działania wiatru nawet słabego, a jego siła nośna pozwalała na wyniesienie kamery na wysokość nie większą niż 100 m. W tej sytuacji postanowiono wykorzystać doświadczenia Czechosłowackiej Akademii Nauk i skonstruowano motolotnię sterowaną radiem jako urządzenie wynoszenia kamery fotograficznej. Motolotnia posiada łatwość pilotażu oraz może stabilnie poruszać się wzdłuż zadanych szeregów.

Motolotnia to model samolotu silnikowego ze skrzydłem w postaci lotni typu Rogallo. Sterowana jest ona z ziemi urządzeniem radiowym nadawczo-odbiorczym firmy Grundig, w którym wykorzystano sterowanie pięcioma serwomechanizmami, a są to: stery głębokościowy i kierunkowy, obroty silnika, wyzwalanie migawki i przewijanie filmu w kamerze.

Motolotnia jest przystosowana do zamontowania w jej korpusie kamer Hasselblad MK-70, i EI-500, oraz wielospektralnej kamery NAC MB-470.

Kamera NAC MB-470 jest kamerą czteroobiektywową wyposażoną w filtry przepuszczające promieniowanie w czterech pasmach widma (niebieski, zielony, czerwony i podczerwony). Do tworzenia kompozycji barwnych ze zdjęć otrzymanych za pomocą wspomnianej kamery, używa się najczęściej przeglądarki addytywnej firmy NAC Mini Viewer AC-70. W zależności od zastosowanych filtrów oraz użytej siły światła na ekranie przeglądarki można otrzymać wielorakie kompozycje barwne tych samych zdjęć. Przeglądarka została zmodyfikowana w stosunku do wersji fabrycznej i dzięki temu posiada możliwość rejestracji kompozycji barwnych bezpośrednio z ekranu na fotograficzny papier barwny metodą stykową. Zdjęcia takie stanowią materiał wyjściowy do wizualnej interpretacji.