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# DATA ACQUISITION FOR REMOTE SENSING

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## 1. General Remarks

The term "remote sensing" is used here for all image forming data acquisition systems within the electromagnetic spectrum. This means that the visible light and in particular the photographic systems, which are still the most important data acquisition systems in remote sensing, are included. This short paper does not intend to cover the whole subject but only some experiences and visible trends out of the daily routine of Hansa Luftbild German Air Surveys.

## 2. Platforms for Data Acquisition

A private company like Hansa Luftbild can practically only use normal civilian type aircraft. Satellites are out of question anyhow, balloons and blimps are practical for test-flights only and helicopters cannot compete with aircrafts as far as economy and stability are concerned except for some special applications. The choice of the aircraft type depends mainly on the required maximum flying altitude or minimum airspeed: for 10.000 - 15.000 meters Jets, for 7.000 - 10.000 meters turboprops, for 4.000 - 7.000 meters conventional propeller aircraft with super- or turbo-chargers and for very low altitudes aircrafts with STOL characteristics. The possibility for short field take-off is mostly not used, however, the possibility of flying at very low airspeeds. In this respect it is important to note that because of the stability required the minimum survey speed is normally considerably higher than the so-called "safe minimum speed" as given by the manufacturer. Other important criteria are the range or endurance and the economy. The latter leads more and more to single engine aircrafts (of course not for flights with thermal infrared scanners). The most important instruments for flying the aircraft on the survey profile are the artificial horizon, the slaved gyro compass and the barometric altimeter. The radio equipment required depends on local conditions. In Germany a complete equipment for instrument flying is mandatory.

## 3. Navigation

There were no real new developments in the field of electronic or automatic navigation for survey flying within the last ten years except for the improvement of navigation computers which followed the general computer development. The standard system is still the doppler navigation. Inertial systems, today standard equipment in all intercontinental jets, are too expensive. Less expensive are so-called VLF-systems, which are using signals from the Omega and the US Navy communication system and can be used all over the world. However, up to now they have not obtained the accuracy required for survey flights. Satellite navigation in aircraft is still in the far future. Since the areas which are not covered by suitable maps or small scale aerial-, radar- or satellite-photographs are getting smaller all the time, the need for electronic navigation systems for survey flights is decreasing accordingly. Today visual navigation is the routine in survey flights and gives the highest accuracies if modern navigation telescopes as for instance the Zeiss NT 2 are used. There are of course limits for visual navigation for instance over sea, over large forest areas or at night (for instance for thermal scanning).

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Visual navigation at night with good results was practised over cities and high density areas (as for instance the Ruhr-District). In other areas moon- or twilight may be required. The vertical navigation is based exclusively on the barometric altimeter. Theoretically inertial systems could be used for vertical navigation by integrating altitude differences in the navigation computer, but up to now there is no application of this sort in civil aviation, maybe for reasons of costs. The use of radar or laser altimeters results in heights of the aircraft above ground, this means that within the frame of remote sensing they are data acquisition systems and not navigation systems.

## 4. Scales and Focal Length

Scale and focal length for aerial photography are normally specified by the user. He must, however, take into consideration the technical limits of the system. For small scale photography this limit is the service ceiling of the available aircraft. The latest models of the Learjet are licensed for flights up to 51.000'. This corresponds to a scale of approximately 1:180.000 if a super-wide-angle camera is used. For large scales the technical limit is the minimum airspeed. With a ground speed of 150 kilometers per hour or 80 knots, a minimum cycle time of the camera system of 2 sec. and a 60 % overlap the largest possible scale is theoretically 1:900. Practically the largest possible scale is about 1:1.000 depending on wind effects, changes of airspeed etc. Another limit in large scale photography is reduced resolution due to image movement. In the example above the theoretical image movement is approximately 50 µm if the shortest possible exposure time of 1/1.000 second is used, which is however seldom possible due to the limited sensitivity of the film material used. If in large scale photography the dead spots and radial displacements of buildings should be kept at a minimum a very long focal length, for instance the RMK 60/23 might be used.
However, a long focal length requires a particularly careful navigation and flying technique. This may be demonstrated with an example: a difference of $2^{0}$ in longitudinal attitude between two successive photographs made with 60 cm focal length reduces the longitudinal overlap from 60 % to 50 %. This correlation between longitudinal and lateral overlaps and the focal length is often neglected in specifications for aerial photography.

## 5. Weather Conditions

Meteorology is still one of the most important subjects when flying with remote sensing systems. Even radar systems are not completely independent from weather, since rain and hail reflect micro waves. The most important factors are clouds, haze, wind and turbulence. It is always a standard question how many photographic days one can expect for a certain area in a certain period. This question cannot be answered in this form since there is no real definition of a "photographic day". The time required to fly a small project may be only a few hours. It is then a question of standby organization and distance from base to survey area if a suitable weather situation which is only of short duration can be used. It can be said from experience that an aircraft stationed from February to November in Germany for project areas with average distribution will fly during this period approximately 200 to 300 hours. For decreasing flying heights the chances for suitable weather conditions are increasing, in particular if no direct sunlight is required. In Lower Saxony for instance the dates of photography for cadastral projects at scales of 1:2.000 to 1:3.000 are scheduled several months in advance. Up to now there were only a few cases where the photography was delayed up to 24 hours.

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## 6. Photography

There were no important developments in the field of black and white photography during the last years except for the increased application of developing machines, in particular the Kodak-Versamat. Experiments to use the Kodak "High Definition Reconnaissance Films" in mapping cameras did so far not give the results expected. There is an increased application of color-infrared- or false-color-film for documentation and biological interpretation of trees in city areas. In order to get an optimal color reproduction for this purpose it is necessary to make a test flight for every emulsion. The results of this test flight in combination with the actual meteorological conditions define the filter combination to be used (Zeiss C and D, Wratten 12 and 15, CC 30B and 80B). Additional color corrections are possible during the developing and by chemical treatment after the developing.

For normal color photography at Hansa Luftbild the Ektachrome MS Aerographic Diapositive-Film is used almost exclusively at this time. With the right developing technique this film allows extreme underexposures (2 to 3 stop) and is therefore particularly suited for photography below clouds and during wintertime. Experience has shown that under such conditions the results are better than with black and white material. The original film is used for interpretation and stereo-plotting. Light-prove color-copies can be made with the Cibachrome procedure, normal and less expensive color-copies with the corresponding Kodak procedure. Black and white copies can be made via a negative or directly on Agfa AR 150 reversal paper. So there is no practical reason for using color negative films.

## 7. Flying with a Scanner

Concerning the general execution of a survey flight there is no basic difference between flying with a thermal or multi-spectral scanner or mapping camera. The scanners normally used at this time have no remote control and need a three men crew therefore. In addition there is a higher demand on the stability of the aircraft since changes in pitch effect the results of the scanner directly and bank angles as soon as they exceed the automatic electronic correction which is mostly $\pm 5^{\circ}$. There is a solution to this problem by mounting the scanner on a gyro stabilized platform. With such an installation the aircraft can directly follow curved lines as for instance rivers for thermal imagery instead of flying individual flight lines.

## Abstract

The term "remote sensing" is here used as a general concept which includes data acquisition in the visible region which still is the most important one for practical work. The brief paper will outline a few specific characteristics of the flight technique used in the Federal Republic of Germany and recent practical experience regarding aircraft, acquisition hardware and materials. It will deal with recent development in navigation and flight design as well.

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## Zusammenfassung

Das Wort "Fernerkundung" wird hier als übergeordneter Begriff benutzt, der die Aufnahmetechnik im Bereich des sichtbaren Lichts, den in der praktischen Anwendung nach wie vor bedeutendsten Bereich, einschließt. In dem Kurzreferat wird auf einige charakteristische Merkmale in der Aufnahmetechnik in der Bundesrepublik hingewiesen und über besondere praktische Erfahrungen aus der allerjüngsten Zeit mit Meßflugzeugen, Aufnahmegeräten und -materialien sowie bei der Navigation und Flugdurchführung berichtet.

## Résumé

L'exposé aborde la technique de prise de vues dans la zone de la lumière visible que demeure un des champs d'application les plus importants de la télédétection. Il décrit quelques aspects particuliers de la technique de prise de vues en République Fédérale d'Allemagne et commente les expériences pratiques acquises récemment avec les avions-photographes, le matériel (appareils et films), les méthodes de navigation et de couverture.

## Resumen

El término "exploración remota" se emplea aquí como concepto general que incluye la técnica de vuelos en la región de la luz visible que sigue siendo la más importante en la práctica. Esta breve conferencia destaca algunas características típicas de la técnica de vuelos empleada en la República Federal de Alemania e informa sobre las experiencias prácticas más recientes hechas con aviones fotogramétricos, equipo y material fotográficos, así como en la navegación y la ejecución de los vuelos.

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