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# IMAGE QUALITY IMPROVEMENT BY FORWARD MOTION COMPENSATION

H.-K. Meier, Oberkochen

## 1. Introduction

The aerial photo quality is of decisive importance for the precision and - even more - the economy of photogrammetric plotting because missing information cannot be added later or only at considerable cost.

Major and minor advances and improvements have been made at all times and have had a continous influence on photogrammetric practice.

In this development work the major elements - lens, film, and forward motion - have independently been subject to rather differing influences even though they interact heavily in aerial photogrammetry.

This interdependence is duly taken into account in the following considerations on advances and improvements.

## 2. Lens Developments and Current Status

The advances and the state-of-the-art regarding the image quality of taking lenses can be illustrated by means of the following Zeiss wide-angle lenses:

| | |
|---|---|
| Topogon 6.3/100 | Status 1935 |
| Pleogon 5.6/153 | Status 1955 |
| Pleogon A 2 4/153 | Status 1975 |

In 1935, the fast new Zeiss Topogon wide-angle lens brought a major advance compared to the wide-angle lenses available at the time.

In 1955, the Zeiss Pleogon was the first Zeiss high-performance wide-angle lens developed after the fresh start in Oberkochen making use of the potential offered by lens coating.

Finally the Zeiss Pleogon A 2, a virtually distortion-free series-produced high-performance lens featuring A characteristics, represents the current state of the art. The associated technical data are given in Fig. 1.

| | 1935 Topogon | 1955 Pleogon | 1975 Pleogon A 2 |
|---|---|---|---|
| Focal length | 100 mm | 153 mm | 153 mm |
| Negative size | 18 cm x 18 cm<br>illuminated up to 10.5 cm image height | 23 cm x 23 cm<br>fully illuminated | 23 cm x 23 cm<br>fully illuminated |
| Angular field | 94° | 93.5° | 93.5° |
| Aperture | f/6.3 | f/5.6 | f/4 |
| Illumination | | * | * |
| Center | 100 % | 100 % (127 %) | 100 % (248 %) |
| Corner (46°) | 14 % | 26 % ( 33 %) | 26 % ( 65 %) |
| Square res. dist. | 32 µm | 2.7 µm | 1.5 µm |
| Spectral range | Pan | Pan | Pan + IR |

*) Topogon center = 100 %

Fig. 1: Technical Data of Zeiss Wide-Angle Lenses

The aperture (speed) increase, the corrected spectral range expansion and the light loss and distortion reductions are worth mentioning.

The image quality improvements can be illustrated by means of modulation transfer functions (MTF) computed for these lenses. Fig. 2 gives the AWAM (Area Weighted Average Modulation) curves for full aperture and stepped down one stop.

It can be seen that the progress from the Topogon to the Pleogon is essentially characterized by negative size (focal length) and speed increases and by light loss and distortion reductions, while the image quality remained virtually the same.

Apart from another remarkable speed increase and enhanced spectral correction up to the IR region, the development of the Pleogon A 2 brought about a noticeable image quality improvement. The AWAM curve for the Pleogon A 2 given in Fig. 2 clearly illustrates this.

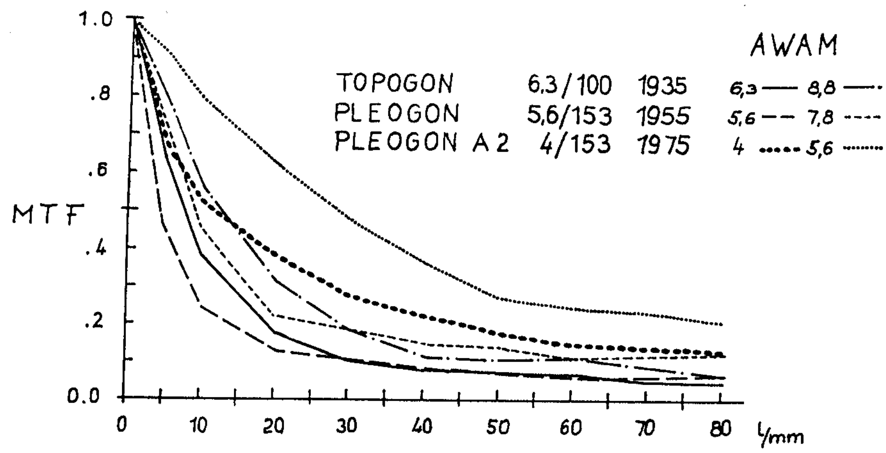


Fig. 2: Image Quality (AWAM) of Zeiss Wide-Angle Lenses

The current state of the art was achieved by advances in glass melting, sophisticated modern computing methods and a considerable increase in the number of optical elements. Detail improvements made in the following years resulted in further optimization. The current status shown in Fig. 3 is used as the basis for all further considerations.

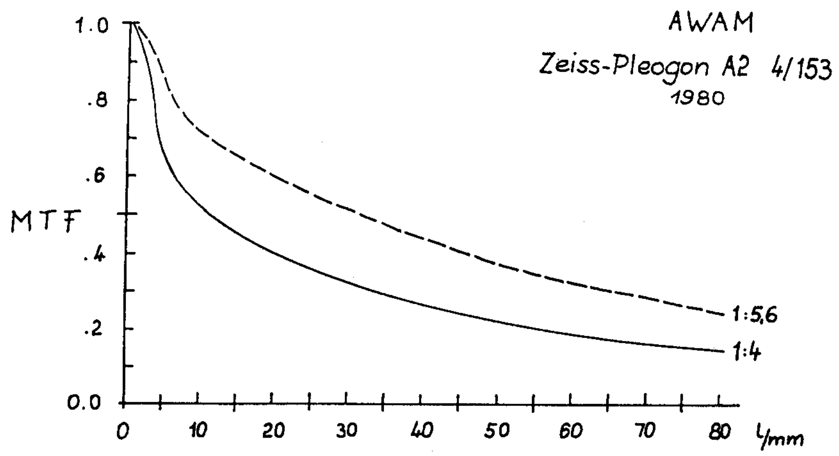


Fig. 3: Zeiss Pleogon A 2 4/153 Modulation Transfer (1980)

## 3. Characteristical Data of Modern Aerial Film Emulsions

Just as much as the taking lenses, aerial film has also been subject to development. Not only the dimensional stability of the substrates but also the speed, grain and modulation transfer of the emulsions have been improved. Contradictory demands - e.g. for fine grain and high speed - has to be optimized by means of compromises from which the user has to select the film best suited to his requirements.

For details refer to the literature /6/, /7/, /14/, /15/. Relevant for this investigation is the relationship between modulation transfer and speed shown for selected common films in Fig. 4.

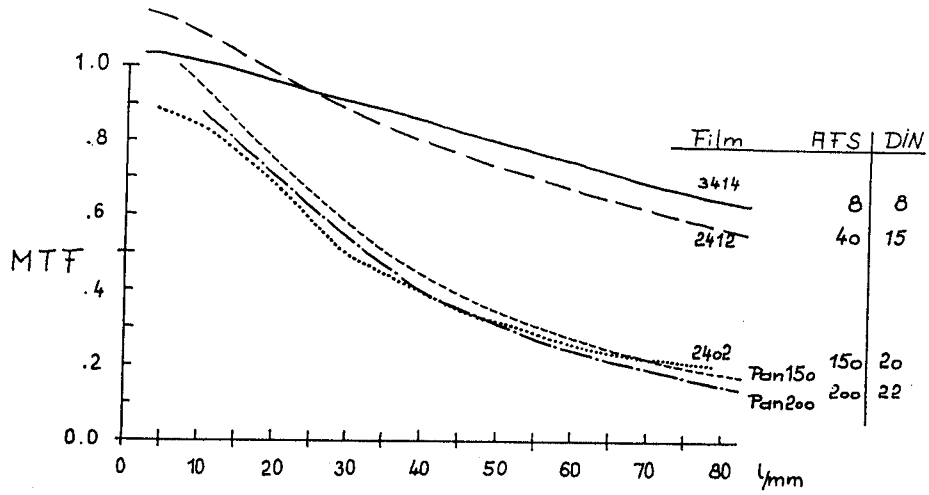


Fig. 4: Speed and Modulation Transfer of Aerial Films
MTF = Modulation Transfer Function
AFS = Aerial Film Speed
DIN = DIN Speed

It can be seen clearly that modulation transfer and film speed are interdependent. Film with an AFS of about 200 has normally been used for practical photo flights, but tests made with AFS 40 or 8 film /1/ have shown impressive quality improvements in applications where the environmental conditions or the instruments allowed the use of such low speeds.
Fig.4 also shows that the gap between the described emulsions provides room for films with an in-between MTF/AFS combination.

## 4. Image Motion

### 4.1 Effect on Image Quality

The effect of image motion on the image quality has been described and discussed in modulation transfer function terms in prior publications /10/. These discussions resulted in the specification of limits up to which image motion was acceptable. Normally 25 µm to 30 µm were considered acceptable, but occasionally even 40 µm had to be accepted. From these limits and the scale and flying speed parameters the exposure time was calculated in a first step and the aperture and spectral filtering in a further step.

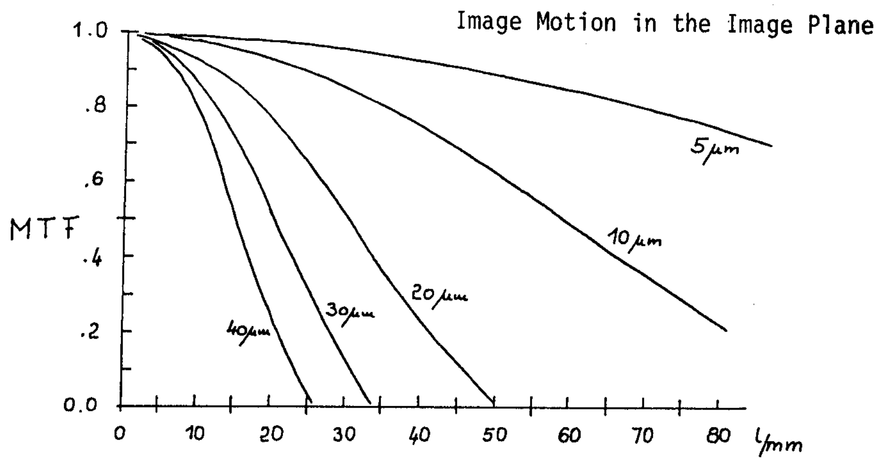


Fig. 5: Modulation Transfer of Image Motion

Fig. 5 shows clearly that image motion always reduces the image quality. At low frequencies this degradation less noticeable, but at high frequencies and in particular with respect to the resolution, image motion sets clear limits.

## 4.2 Effects on the Image Geometry

Little importance has up to now been attached to the effect of image motion on the image geometry. However, as an introduction to forward motion compensation, a discussion of this effect may be useful /16/. Fig. 6 shows the conditions.

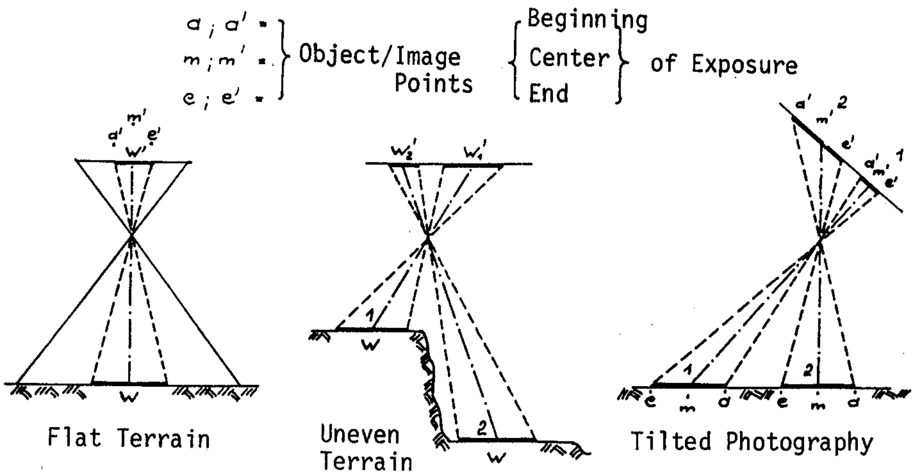


Fig. 6: Effect of Image Motion on Image Geometry

If the terrain is even and photography is vertical, forward motion causes all points to be represented by lines with a length w' usually of 20 µm to 30 µm. This can be seen as a large number of consecutive central-perspective subphotos. During mapping, the floating mark is set to the center of the lines to obtain the central perspective m'. Since lines $\overline{a'm'}$ and $\overline{m'e'}$ of all points in the photo are identical and of same size, the central perspective is not affected by this method.

If the terrain is uneven, the lines differ in lenght according to the differences in elevation, but $\overline{a'm'}$ and $\overline{m'e'}$ are identical for every point. Central perspective m' is again achieved by central setting.

However, deviations occur with tilted photography. $\overline{a'm'}$ is no longer identical with $\overline{m'e'}$, and the deviations vary depending on the location of the points. Central setting between a' and e' no longer produces m', i.e. strict central perspective is not obtained. In practice, however, the deviations are much less than 1 µm and do not adversely affect the precision as long as the photo tilt does not exceed 5°.

## 5. Image Motion Compensation

The measures taken in the past against image motion all concentrated on reducing the exposure time by developing and using high-efficiency rotating-disk shutters, fast lenses and fast emulsions.

Compensation methods and means were given less attention /8/. They mainly emanated from the requirements and experience gained in military reconnaissance. In 1948 already, the following was stated very clearly: "The moving film principle is one of controversy to the photogrammetrist. It was first believed to be valuable only to reconnaissance... . After a comparison of a pair of photographs has been made under the stereoscope exposed with the moving film principle and without, one is easily convinced that the moving film principle is important in the field of photogrammetry."

Later, an IMC magazine for the KC 6 A Fairchild mapping camera provided the instrumental means, but the method did not arouse any interest and more than 30 years had to pass before it was widely introduced in practice.

## 5.1 FMC Approaches

Regarding the camera, there are two approaches to implement FMC, namely

- compensation by film feed/translation TFMC
- compensation by camera rotation RFMC

The conditions are illustrated in Fig. 7.

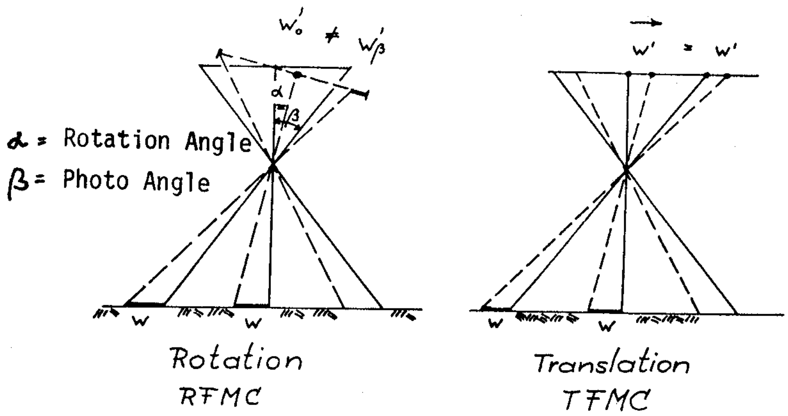


Fig. 7: Forward Motion Compensation by Rotation of Translation

## 5.2 Effect of FMC on the Image Quality

In considering the effects of the two methods on the image quality, it is assumed that the relative motion w between the camera and the object results in an forward motion w' that is constant in the whole negative (vertical photography, flat terrain).
Compensation by film translation during exposure in the amount w' is basically possible with TFMC precision.
On the other hand, compensation by camera rotation α results in compensation amounts w' which depend on the angle ß , i.e. are by no means constant.
The following applies:

$$w'_ß = w'_0 \times 1/\cos^2 ß$$

and, with ß = 37° (wide-angle edge)

$$w'_ß = w'_0 \times 1.56$$

This shows that, with wide-angle cameras, rotational FMC only allows 56 % compensation for central setting to ± 28 %.
Thus, with RFMC, a considerable amount of forward motion remains that still contributes to image quality degradation.

## 5.3 Effects of FMC on the Image Geometry

It may be assumed that the fear of image geometry degradation by FMC was the reason why earlier proposals to implement FMC were not followed through. However, this problem has been studied intensively a short time ago /2/, /11/, /16/.

This is why only a short summary need be given in the following.

For TFMC, i.e. forward motion compensation by film translation, the discussion is based on the considerations presented in section 4.2. Fig. 8 shows the conditions.

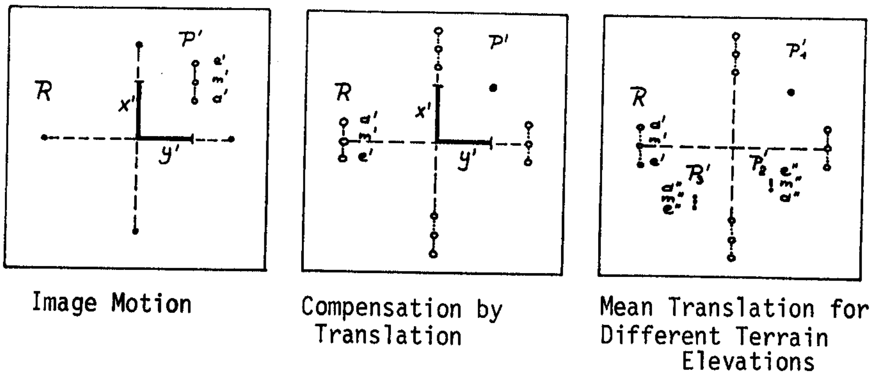


Fig. 8: Effect of TFMC on the Image Geometry
(vertical photography, flat terrain, error-free TFMC)

As mentioned in section 4.2, image motion causes points to produce lines $\overline{a'e'} = w'$ and the fiducial marks to produce points. Assuming that the terrain is flat, photography is vertical and TFMC is error-free, TFMC reverses these conditions: Points remain points and the fiducial marks produce traces with a length of $R_{a'e'} = w'$. Central floating mark setting produces the central perspective m'. In practice, however, the assumed conditions do not exist. Differences in terrain elevations prevent precise compensation except for points located on the mean terrain elevation h. Points with differences in elevation dh still produce traces as follows:

$$\overline{a''e''} = w' \times \Delta h/h$$

Undisturbed central perspective can be achieved in this case too by setting to m''. Disturbances occur only with tilted photography. The conditions then are the same as with uncompensated forward motion as described in 4.2, i.e. the traces are no longer symmetrical to m' and result in

$$\overline{a'm'} \neq \overline{m'e'}$$

However, with normal photographs these deviations are so small that they can be ignored in practice just as in photography taken without forward motion compensation.

To summarize it can be said that TFMC does not adversely affect the image geometry in practice.

Without taking the discussion to extremes, it may be said that this applies similarly also to RFMC.

With rotational compensation, the point traces are longer as explained in section 5.2 and central setting to $\overline{a''e''}$ does not yield m'', but these deviations from strict central perspective can also be ignored in practice.

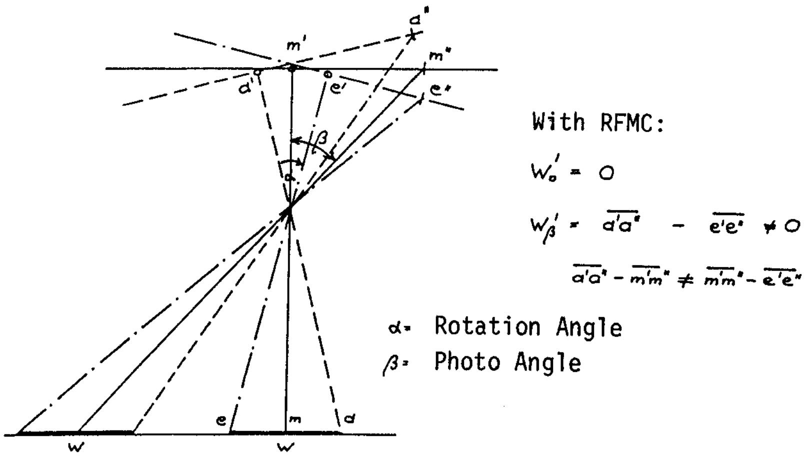


Fig. 9: Image Geometry with Rotational FMC

Thus the reason why TFMC was preferred to RFMC is not image geometry but the limited forward motion compensation potential, i.e. the non-optimum image quality. Another reason is the problem of rotating the camera with the required angular precision. (At a focal length of 153 mm, a compensation precision of 0.005 mm in the image plane would require an angular rotation precision of 7 seconds of arc!)

## 6. FMC Implementation in Zeiss Survey Cameras

At the beginning of 1984, the Zeiss line of aerial survey cameras was expanded by the CC 24 compensation magazine which allows image motion to be compensated in the flying direction (forward motion compensation) /11/. Since then, a large number of units have been commissioned and used. The following requirements had to be met during development:

- Compatibility with the existing RMK system
- Use with lens cones for all focal lengths
- Use of the internal v/h overlap control signal for FMC control
- Implementation of forward motion compensation by translation (TFMC)

To minimize camera modifications the compromise was accepted that the fiducial marks are deformed to traces instead of being exposed as points. This provides the advantage that precision adjustment for central fiducial mark exposure is not required. Furthermore, the trace length can be used as a measure of the amount of compensating translation applied to each photo. The result of the development efforts is shown in Fig. 10.

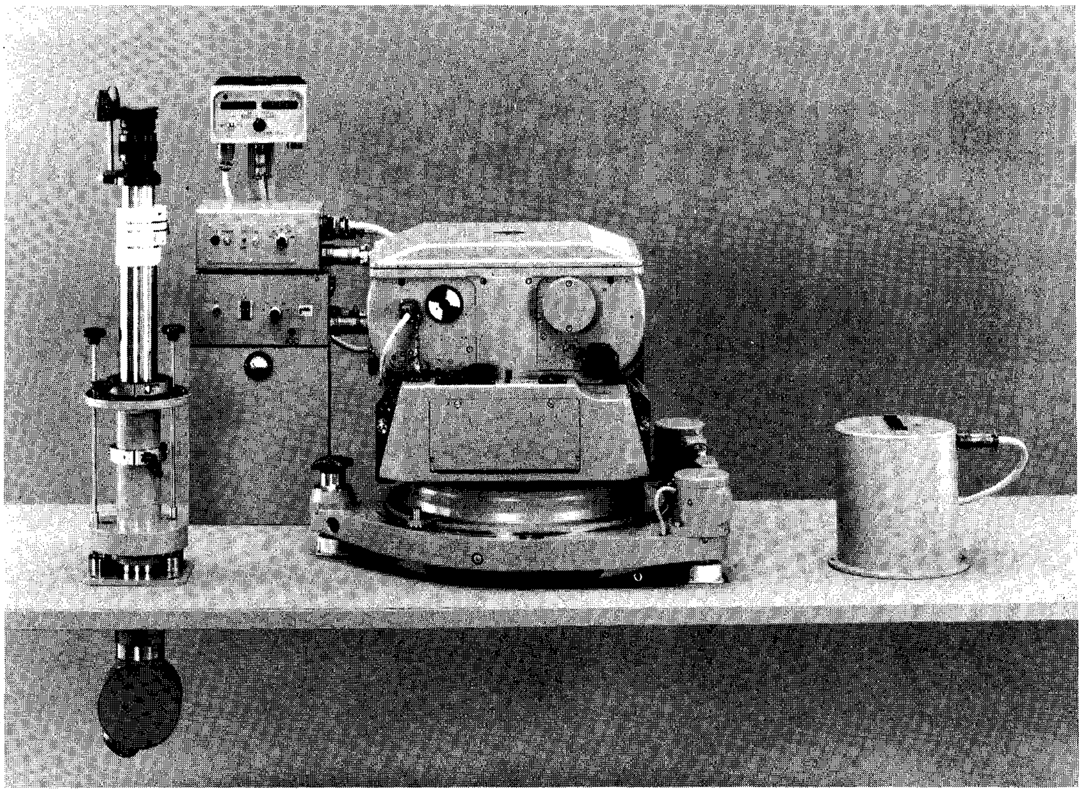

Fig. 10: Zeiss RMK with CC 24 Compensation Magazine and CC Con Electronic Control Unit

Integration in the Zeiss RMK system is shown in Fig. 11.

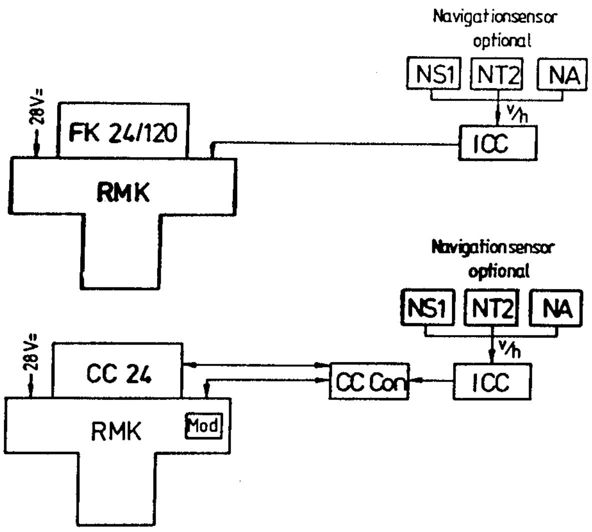


Fig. 11: Integration of the CC 24 Compensation Magazine with CC Con Control Unit in the Zeiss RMK System

The technical data are as follows:

| | | |
|---|---|---|
| Film width: | ) | 24 cm unperforated (9 1/2") |
| Film length: | ) as for FK 24/120 | 120 m or 150 m |
| Film flattening: | ) | by vacuum |

Forward motion compensation by translation (TFMC):

- Maximum translation 30 mm/sec
- Lowest shutter speed: 1/100 or 1/50 sec.

## 7. Interaction of the Elements Lens - Film - Forward Motion

Modulation transfer functions are particularly useful in the study of system characteristics because the functions of the individual elements - lens, film and forward motion in this instance - can easily be combined by multiplication as shown in Fig. 12.

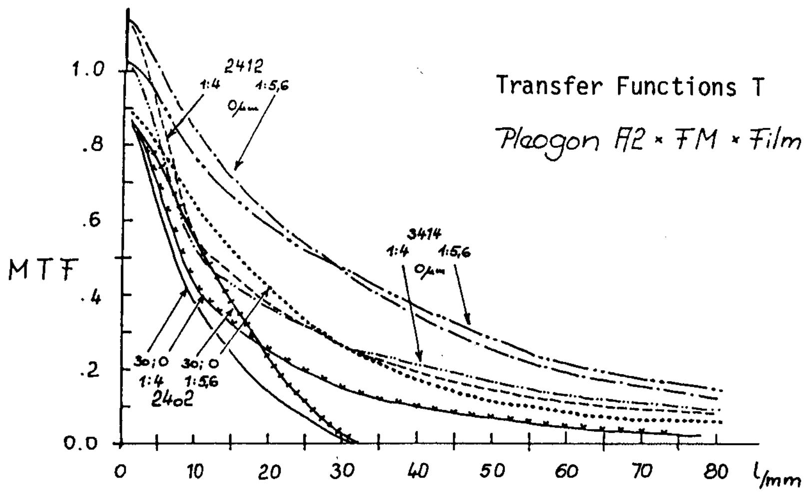


Fig. 12: Modulation Transfer of the System Zeiss Pleogon A 2/FMC/Film

The following conclusions can be drawn:

- Forward motion compensation provides considerable improvement at high frequencies (20 to 50 lp/mm) as the comparison between 1:4/30 µm/2402 and 1:4/0 µm/2402 clearly shows. Even if all other conditions remain unchanged, FMC brings about a clear improvement.
- If the exposure time can be doubled compared to the basic 1:4/2402 and the forward motion can be compensated, stepping down the lens from f/4 to f/5.6 results in another noticeable quality improvemnet (1:5.6/0 µm/2402). If the forward motion is not compensated and only the lens is stepped down (1:5.6/30 µm/2402), the quality increase is relatively small.
- If the exposure time can be quintupled compared to the basic 1:4/2402 or if the illumination is adequate, a high-resolution AFS 40 emulsion (e.g. 2412) can be used and a further significant increase can be obtained for high frequencies.
  The finer grain also improves the visual quality impression.
- Using even slower but higher-resolution AFS 8 emulsions (e.g. 3414) does not cause further noticeable improvement.

To properly assess these quality improvements, a comparison with the state of the art achieved in 1955 with the Pleogon 5.6/153 (Fig. 2) might be useful.
Fig. 13 compares the

Pleogon 5.6/153: 5.6/30 µm/2402 1955
Pleogon A 2 4/153: 5.6/30 µm/2402 1975

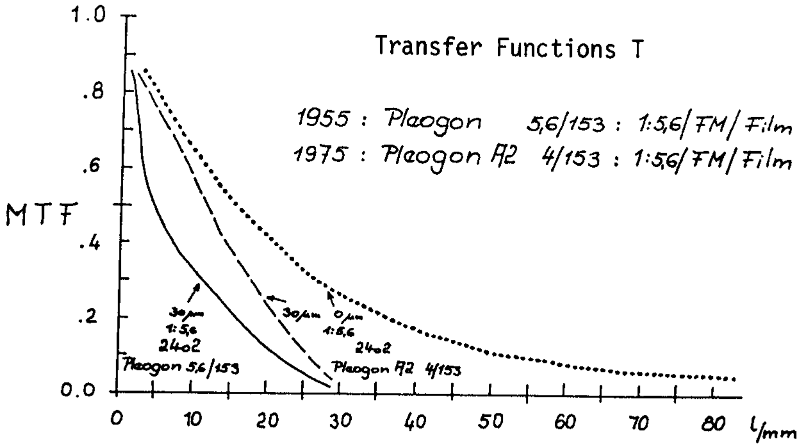


Fig. 13: Effect of the Optical Quality Improvement of the Pleogon A 2 4/153 (1975) over the Pleogon 5.6/153 (1955) on the Lens/FM/Film System

This figure shows that 20 years of intensive optical development work on the overall system only brought advances in the low frequency range and that the breakthrough in the range of medium and high frequencies was achieved by means of FMC.

## 8. Effects on Practical Photoflights

### 8.1 Relationship between Image Quality and Required Exposure Extension

The discussed major elements - lens/forward motion/film - not only affect the quality of the end product as shown above, but require changes in photoflight planning. The exposure merits special attention. Stepping down the lens or using less sensitive emulsions necessitates larger exposure. In practice possibilities and conditions have to be assessed on the base of the resulting image quality improvement. To illustrate the consequences, the modulation transfer functions have been compressed to image quality numbers or image quality differences and compared to the required exposure increase. In /5/, an image quality scale based on subjective assessment has been derived from the transfer functions in such a way that the sequence of the quality scale figures conforms to the subjective assessment ranking.

An image quality gain $\Delta g$ has been evolved by applying these findings to the problem discussed in this paper.

$$\Delta g = \log \frac{\int_0^n T \, dn}{\int_0^n T_0 \, dn}$$

Transfer functions T correspond to the MTF multiplications for the relevant lens/forward motion/film combinations.

$T_0$ is the transfer function for the basic combination Pleogon A 2 4/153 for f/4, forward motion of 30 µm and 2402 film (1:4/30 µm/2402). The integration was computed for n = 0 to 80 l/mm to account for the viewing conditions (magnification about 10x) and the significance of minute detail in photogrammetry.

For the relationship of required exposure B, an extension factor b was introduced as follows:

$$B/B_0 = b = b_1 \times b_2$$

$B_0$ is the exposure required by the basic combination defined above.

The relationships between the aperture stop numbers,

$$\text{e.g. } (f4/f5.6)^2 = b_1$$

and between the AFS film speeds,

$$\text{e.g. AFS 2402/AFS 2412} = 200/40 = b_2$$

have been taken into account.

The results of these considerations for the defined combinations are shown in Fig. 14.

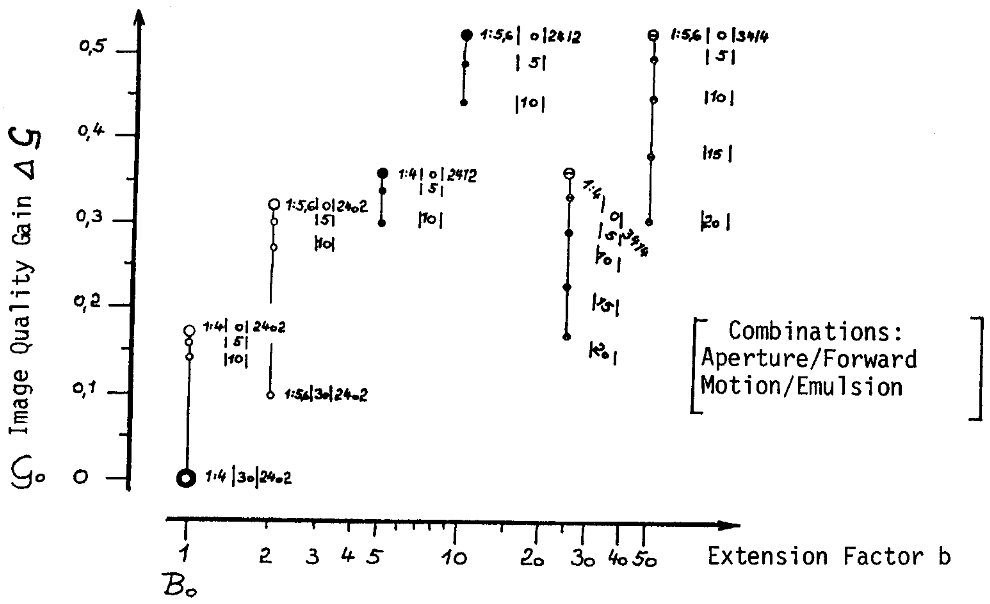


Fig. 14: Relationship between the Image Quality Gain and the Exposure Extension Required with the Zeiss Pleogon A 2 4/153

The combination Full aperture/forward motion 30 µm/2402 emulsion (1:4/30 µm/2402) is used as the basic combination. If forward motion is compensated, i.e. if the combination 1:4/0/2402 is used, a sizeable image quality gain is achieved without the exposure having to be extended (b = 1). If the exposure and the emulsion are retained and the lens is stepped down to f/5.6, the image quality gain is markedly lower and obtained at the expense of a doubled exposure (b = 2). This explanation should help in understanding the above illustration; it combines, coarsens and summarizes earlier statements and illustrates the possible gains and the price that has to be paid for them. Conclusions can be drawn for field use. The MTFs given in Fig. 12 should be used for detailed analysis.

The preceding discussion dealt with the image quality improvement that can be obtained by compensating that part of image motion that is caused by the forward motion of the aircraft. However, it is well known that image motion is also caused by other factors which cannot be compensated fully. This is why the notion 0 µm image motion is not sensible. Only little reliable information is currently available on the magnitude of the remaining image motion. The influence of the prevailing environmental conditions can be assumed to be high. The above discussion is therefore completed by introducing combinations featuring residual image motions of 5 to 20 µm. The resulting image quality gains are also shown in Fig. 14.

It can be seen that a residual image motion of 5 µm reduces the image quality gain only slightly. The reduction obviously is greatest when the image quality is highest (5.6/0/2412 ⟶ 5.6/5 µm/2412).

If the residual image motion is 10 µm, the quality degradation becomes more significant, but the relationship between the various combinations is still maintained to a large extent.

For the 3414 film, image motions of 15 and 20 µm have to be introduced because of the required high extension factors. The image quality gain then falls off dramatically.

Regarding the magnitude of the residual image motion, the dependence on the extension factor has to be considered if the extension - at otherwise identical conditions - is obtained by increasing the exposure time.
Fig. 14 shows the adverse effect of residual image motion on the desired image quality gain. This problem ought to be analyzed in detail as soon as reliable quantitative residual image motion data is available.

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## 8.2 Image Motion as a Function of the Photo Scale and the Flying Speed

In the above considerations, image motion was referred to the image plane of the taking lens. Image motion depends on the flying speed, the flying height and the focal length. A clear illustration of the magnitudes to be expected is given in Fig. 15.

Using the flying speed, the resulting image motion for selected exposure times can be read off Fig. 15 for all photo scales.

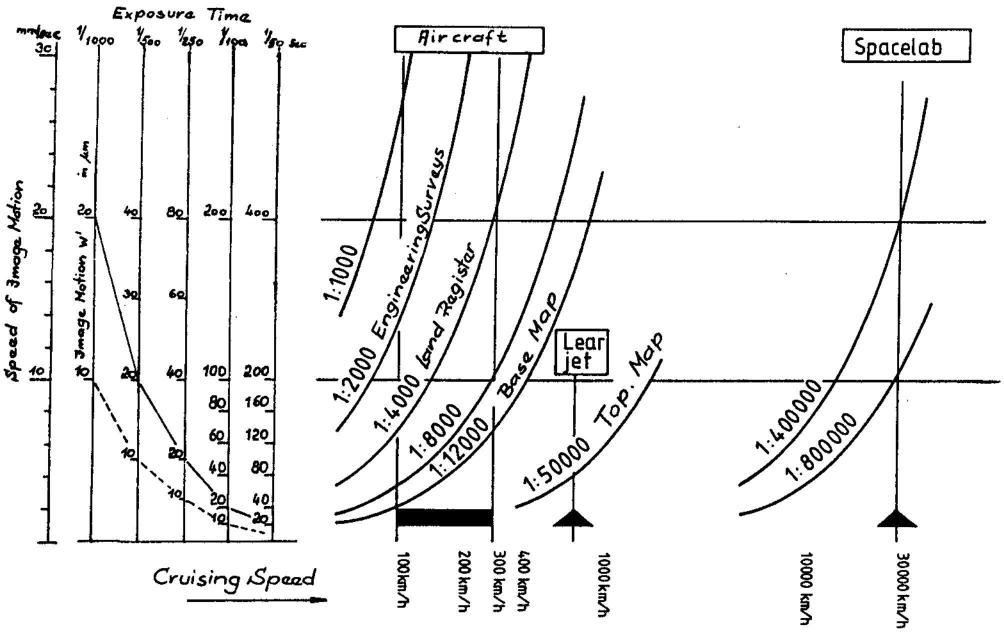


Fig. 15: Image Motion as a Function of Photo Scale and Cruising Speed

Fig. 15 shows:

- With normal aircraft and a shutter speed of 1/250 sec., all photo scales above 1:10 000 will exhibit an image motion of about 20 µm. For high-resolution film emulsions this exposure time is generally too short and 20 µm image motion is not acceptable. The need to use FMC becomes more urgent when larger scales are used. For example, FMC is indispensible for the land register scale of 1:4000 and exposure times of less than 1/500 sec.

- In the topographical scale range using high-altitude jets, image motion at first appears to be rather uncritical. It should be remembered, however, that in small-scale photos in particular the most minute detail should be discernible to allow reliable mapping. The use of high-resolution emulsions can be economically significant especially in this field.

- Regarding satellite photography, reference is made to the "Metric Camera" experiment made near the end of 1983 during the Spacelab D1 mission, which is to be repeated in summer 1986. Because of the unfavourable season and the lack of FMC, a fast AFS 500 film (2402) had to be used during the first mission and exposed with 1/250 sec. /9/, /12/. At a scale of 1:800000, Fig. 15 shows an image motion of 40 µm which affected the image quality noticeably /3/. For the repeat mission, the Zeiss RMK A 30/23 camera will be equipped with CC 24 film magazines, i.e. FMC will be possible. The camera has therefore been converted for a maximum exposure time of 1/50 sec. This clears the path for the use of high-resolution emulsions (e.g. 2412) and a considerable quality gain.

## 9. Results of Precision Investigations

To verify the above considerations, precision investigations were made in August 1983 /11/ and in June 1984 /13/. The photo material was obtained during the "Mannheim" flights made with a RMK A 30/23 at a height of 1220 m, a scale of 1:4000 and a flying speed of v = 200 km/h. The following combinations were investigated:

A) 2402: without FMC : 1/350 sec.; 1:8 /40 µm/2402

B) 2402: with FMC ( 40 µm) : 1/350 sec.; 1:8 / 0 µm/2402

C) 2412: with FMC (140 µm) : 1/100 sec.; 1:6.3/ 0 µm/2412

D) 3414: with FMC (140 µm) : 1/100 sec.; 1:5.6/ 0 µm/3414

Without wanting to preempt the detailed publications the major results can be summarized as follows:

### 9.1 Fiducial Mark Setting Precision

The fiducial marks of aerial survey cameras normally have a diameter of 100 µm. FMC causes them to be deformed in the X direction - disks become ellipses.

In an initial plot made with the Zeiss Planicomp /11/, no significant difference was found between combinations A) and D). Even with combination D), the setting precision with fiducial mark deformation in the X direction to 200 µm remained unchanged at

$$m_{x,y} = 2.2\ \mu m$$

Investigation /13/ was made more painstakingly and with high precision by means of the Zeiss PK 1 Monocomparator. The following fiducial mark setting precision data was found:

| | $m_x$ | $m_y$ | FMC |
|---|---|---|---|
| A) | 0.6 µm | 0.7 µm | 0 |
| B) | 1.1 µm | 0.7 µm | 40 µm |
| C) | 1.6 µm | 0.8 µm | 140 µm |
| D) | 1.3 µm | 0.7 µm | 140 µm |

A significant dependence on the X direction deformed by compensation was found, but the precision (1.6 µm) remains remarkably high even under these conditions.
Effects on the interior orientation resulting from this degradation were not found.

### 9.2 Natural Points Setting Precision

With the Zeiss Planicomp /11/ the following data was found for selected natural points:

| | $M_x$ | $M_y$ | $M_z$ |
|---|---|---|---|
| A) | 1.3 µm | 2.5 µm | 6.3 µm |
| B) | 1.7 µm | 2.7 µm | 6.5 µm |
| D) | 1.2 µm | 2.0 µm | 7.7 µm |

The detailed investigations with the Zeiss PK 1 /13/ produced the following results:

| | $M_x$ | $M_y$ |
|---|---|---|
| A) | 1.6 µm | 1.5 µm |
| B) | 1.0 µm | 1.4 µm |
| C) | 0.9 µm | 1.1 µm |
| D) | 1.1 µm | 1.2 µm |

The planimetric setting precision shows clear improvements as a function of the image quality gain. However, the improvement is not as marked as the operator would guess from the visible quality gain.

## 9.3 Precision of the Central Perspectives

It has already been mentioned that fears FMC might deform the central perspective may have prevented the earlier introduction of FMC. The above theoretical considerations show, however, that these fears are unfounded. Actual field test photographs were not available to prove this; therefore individual models /11/ and bundle strips /13/ were investigated.

After 21 point measurements with combinations A), B) and D), mean observation errors of

$$m'_{x,y} = 8\ \mu m \qquad m'_{z} = 18\ \mu m$$

were found with individual models /11/.

This precision can be expected for this type of lens (normal-angle lens). Systematic deformations by FMC [ B) : 40 µm; C) : 140 µm ] were not found.

The Zeiss PK 1 was used for measuring the natural tie points for bundle strips /13/. "Free" bundle adjustment was performed with Pat-B.

The unit weight errors found with Pat-B express the photogrammetric measurement precision (point identification, point setting, interior orientation) inclusive of photo and instrument errors. Sigma 0 thus represents the geometrical precision of the bundles except for common systematic errors which do not result in contradictions.

| | Sigma 0 from Pat-B |
|---|---|
| A) | 4.7 µm |
| B) | 4.3 µm |
| C) | 2.8 µm |
| D) | 2.7 µm |

These results show clearly that the measurement precision increases if the image quality increases. The extent to which this increase also affects the strip and block precision should be investigated with future verified strip and block adjustments. However, it can be assumed that, if a sufficient number of control points is available, the strip and block precision will exhibit a similar increase.

## References

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Abstract

Suitable equipment is now available for forward motion compensation in the Zeiss RMK system . Examination of the individual components "lens", "image motion " and "film" with respect to their combined influence on the image quality have shown a considerable potential for improvement, in particular with the use of high-resolution emulsions. The fear that compensation might adversely affect the central perspective geometry proved to be ill-founded, both in theory and practice.

On the contrary, it is hoped that the improvement of image quality by higher setting accuracies will ultimately lead to better accuracies in models, strips and blocks. It is also expected that this will have a favourable effect on the accuracy and reliability of interpretations in particular. This is likely to result in a noticeable improvement of the cost-effectiveness in topographic mapping, particularly on small scales. The increase in quality achieved in ortophoto maps is evident.

The large-scale introduction of FMC in practical photogrammetry is therefore strongly recommended.

STEIGERUNG DER BILDQUALITÄT DURCH FORWARD MOTION COMPENSATION

Zusammenfassung

Zur Kompensation von Bildwanderung steht für das Zeiss RMK System jetzt geeignetes Instrumentarium zur Verfügung. Untersuchungen der Einzelkomponenten "Objektiv", "Bildwanderung" und "Film" in ihrem Zusammenwirken auf die Bildqualität zeigen deutliche Steigerungsmöglichkeiten, insbesondere bei Verwendung hochauflösender Emulsionen. Befürchtete Auswirkungen der Kompensation auf die Geometrie der Zentralperspektive konnten weder theoretisch noch praktisch nachgewiesen werden.

Im Gegenteil läßt die Verbesserung der Bildqualität über höhere Einstellgenauigkeiten auch höhere Endgenauigkeiten in Modellen, Streifen und Blöcken erhoffen. Nachhaltige Auswirkungen sind darüber hinaus vor allem in der Sicherheit und Zuverlässigkeit von Interpretationen zu erwarten. Für topographische Kartierungen, insbesondere in kleinen Maßstäben dürfte sich damit die Wirtschaftlichkeit spürbar verbessern lassen. Für Ortophotokarten ist der Qualitätsgewinn sichtbar.

Die breite Einführung von FMC in die photogrammetrische Praxis kann deshalb nachhaltig empfohlen werden.

H.-K. Meier
Carl Zeiss
Geschäftsbereich Vermessung
7082 Oberkochen