Comparison of Information Contents of Different Space Images

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1. ABSTRACT

Images taken from space do have a growing meaning for mapping. It is not a problem to reach a horizontal accuracy sufficient for map scales 1 : 25 000 and smaller or even better, but the main limitation is the identification and interpretation of the objects. The use of SPOT images has been well established in spite of the not optimal ground resolution. A better information contents is represented by the high resolution Russian space photos, but it is not easy to get actual copies. Today the panchromatic camera of the Indian Remote Sensing Satellite IRS-1C represents the highest ground resolution of the commercial available space sensors usable for mapping. Even with the limited radiometric resolution with 6bit (64 gray values), it allows the identification of nearly all elements important for maps 1 : 50 000. The information contents of different space images is compared.

2. Used sensors for mapping

In the University of Hannover we started with mapping using images from space sensors in 1983 with the German Metric Camera test. Since that time we have analyzed nearly all space sensors for their cartographic potential. The following space systems have been investigated:
Metric Camera (MC), German test 1983,
Large Format Camera (LFC), test USA 1984,
images taken with the operational photographic cameras from Russia (CIS): KFA1000, KATE200, MK4, KFA3000, KVR1000 - also named KWR1000, and handled also as digital data under the name DD5,
the operational French line scanner images from the SPOT satellite,
the German test images from the Modular Optoelectronic Multispectral Stereo-Scanner MOMS-02
and the images taken by the operational panchromatic line scanner camera (PAN) of the Indian Remote Sensing Satellite IRS-1C (Jacobsen 1997a and 1997b)

sensor	f [mm]	image size [mm]	flying height [km]	covered area [km]	ground resolution [m/lp]	height / base - ratio
MC	305	230•230	250	188•188	16 - 33	3.3
LFC	305	230•460	225 / 352	170•340 / 260•530	10	1.6
KFA1000	1000	300•300	220 / 350	66•66 / 105•105	5 - 10	8.2
KATE200	200	180•180	220 / 350	200•200 / 315•315	25 - 40	2.8
MK4	300	180•180	220 / 350	132•132 / 210•210	10 - 15	4.2
KFA3000	3000	300•300	220 / 350	22•22 / 35•35	2 - 5	no stereo
KVR1000	1000	180• (180)	220 / 350	26•(26)	(0.75) 2 - 5	no stereo
SPOT	(2086)	(150•150)	830	60•(60)	10/20m pixel	up to 1.0
MOMS-02 MOMS-2P	220/ 660	6000 pixel/ 9000 Pixel	295 390	78• ... 37•... 100•./48•.	13.5/4.5m pixel 16.5/5.8m	1.3 1.3
IRS-1C/1D PAN	980	12 000 (3•4096)	817	70•(84)	5.8m pixel	up to 1.0

table 1: technical data of the used space images

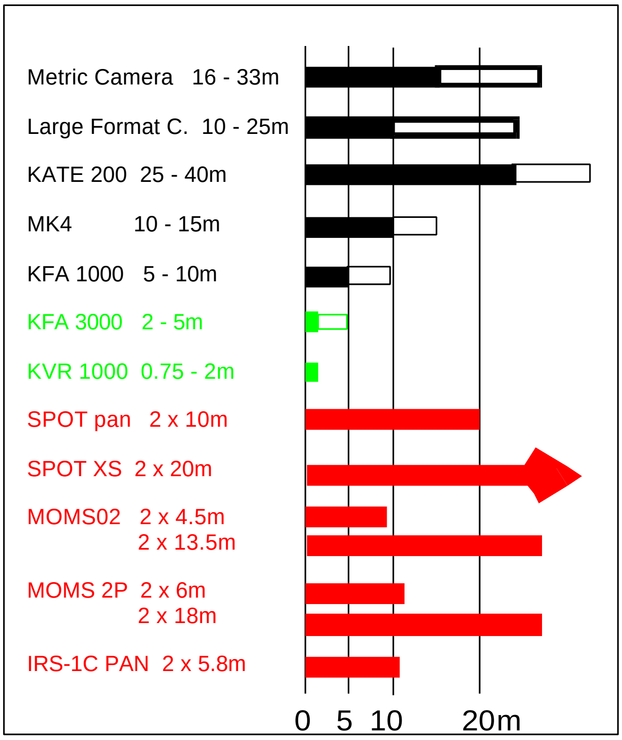


figure 1: ground resolution [m/lp] or size of 2 pixel

1 line pair = 2 pixel

rule of thumb: for mapping 0.1 – 0.2mm/lp in the map scale required

3. Mapping

The geometric potential of the space images can be checked by bundle adjustment (Jacobsen 1994a, 1994b, 1997a). In general the achieved accuracy of the horizontal coordinates of well defined points is much better than required for the creation of topographic maps. In the topographic maps the contour interval and vertical accuracy is quite different and mainly depending upon the area. A sufficient standard deviation of the height can only be determined with space images with a base to height ratio close to 1.0 and in mountainous areas. The vertical component is only important for map creation, in the case of an update usually no correction of the height will be made. For mapping the information contents of the images is more important than the geometric accuracy. An indication of the information contents is the ground resolution (figure 2). But not only these nominal figures, also the radiometric situation is important. This is of course also influenced by the individual imaging conditions like time of the year, sun elevation and atmospheric conditions.

As a rule of thumb, the ground resolution (size of a line pair which just can be separated in the object space [lp/m]) shall not exceed 0.1 up to 0.2mm in the map scale. By experience, the ground resolution corresponds to approximately 2 pixel. So for mapping in the scale 1 : 50 000, a ground resolution of 5 – 10m or a pixel size of 2.5 – 5m should not be exceeded. If this condition cannot be matched by the available images, not the whole required map contents can be extracted. The range between the lower and the upper value of this rule is depending upon the structure of the area and the national map standards.

As shown in figure 2 and table 1, only the film cameras LFC, MK4, KFA1000, KFA3000, KVR1000 and the line scanner MOMS and IRS-1C (1D) are fitting to the conditions for mapping in the scale 1 : 50 000, the LFC and the MK4 only under optimal conditions. But such a rule of thumb has to be checked under working conditions also because of the not so clear photographic resolution, which is very often not realistic.

For an operational mapping actual images should be available, so the tests with the Metric Camera, the Large Format Camera and MOMS are not taken into account. A comparison of the KATE200, the MK4 and the KFA1000 has shown not acceptable results for first both cameras. The resolution of the KFA3000 is excellent, so the large majority of details required for a map 1:50000 can be identified. No stereoscopic coverage is available for these images, so only a mono-plotting is possible based on an existing digital height model. Because of the inclined view, the height information must be available with a standard deviation of two times the horizontal.

For the area of the city Wunstorf, located close to Hannover, panchromatic and multispectral SPOT-, KFA1000-, KVR1000-, IRS-1C PAN- and high altitude photo flight images (1:120 000) are available. A mapping of the area was made with all of them. Not the original KVR1000 images, but heavily compressed digital data with 3m pixel size, corresponding to the contents of 5m pixel size have been used. The IRS-1C PAN-images do have a quantization of 6bit or 64 different gray values. The poor contrast of the original images has to be improved. A not linear look up table resulted in satisfying images.

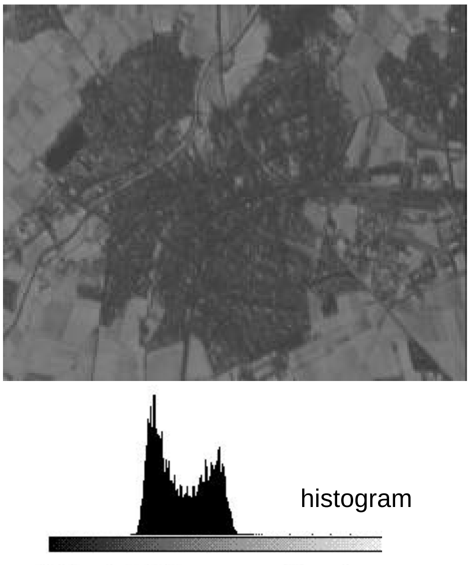
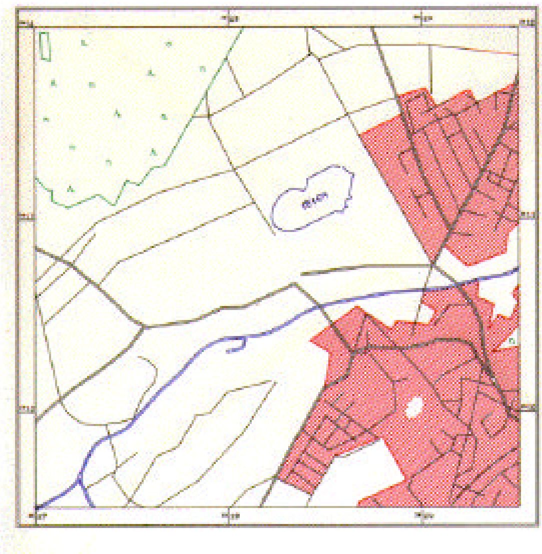


figure 2: IRS-1C PAN Wunstorf
original gray values

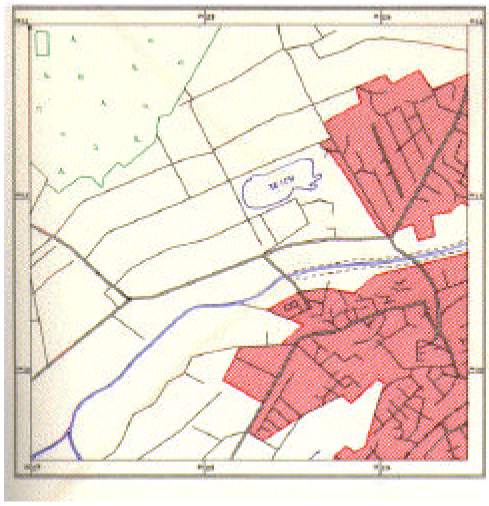
figure 3: IRS-1C PAN Wunstorf
improved image

The IRS-1C PAN-images have been taken in December 1996 with a sun elevation of only 13°. This is below the usually accepted limit. Long shadows are disturbing the object identification, nevertheless nearly all objects available in the topographic map 1 : 50 000 could be mapped. Also with the compressed KVR1000 images the result was satisfying. There was no doubt with the optimal results based on the high altitude photos with a photo scale 1 : 120 000 corresponding to a ground resolution of 3m/lp or a pixel size of 1.5m. With these images all details of the topographic map 1 : 25 000 could be seen.
Not only the pixel size is important, the spectral information supports the object identification. So in spite of the relation of the pixel size by the factor 2, the information contents of the panchromatic and the multispectral SPOT images was approximately the same. In the multispectral images the water bodies do have a good contrast and can be identified more easy than in the higher resolution panchromatic images. But in general the pixel size of SPOT with 10m and 20m is not sufficient for the creation of maps with the contents of German topographic maps 1 : 50 000. Especially the details in the build up areas cannot be seen. Only wide streets can be identified and in the rural areas a separation between a boundary line with a hedge and a small road is not possible. No individual buildings, even if they are large, can be recognized.
The situation with the KFA1000 is better, only in the city itself the identification of streets is difficult. In the area outside the city with individual houses, the buildings can be mapped.

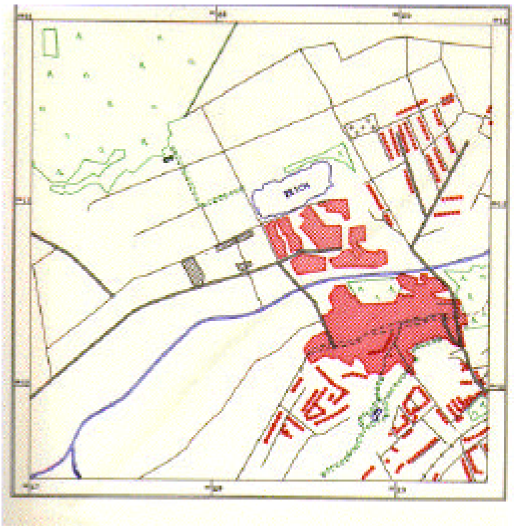
SPOT multispectral



SPOT panchromatic

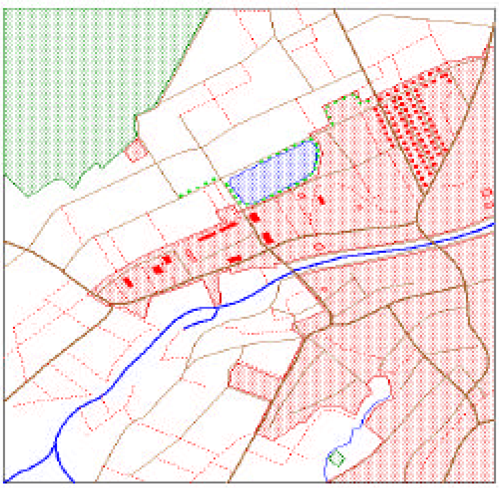


KFA 1000



high altitude photo
1 120 000

IRS-1C PAN



KVR 1000

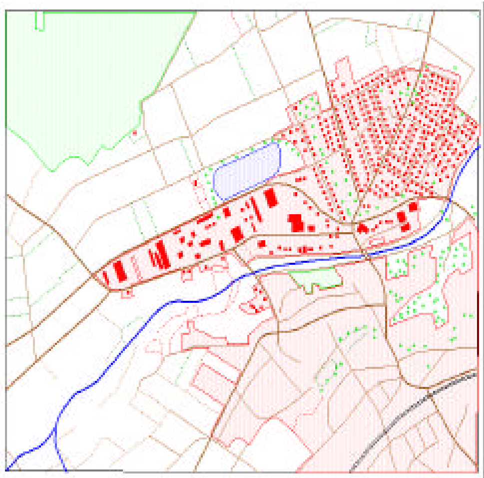


figure 4: area of Wunstorf mapped with different space images

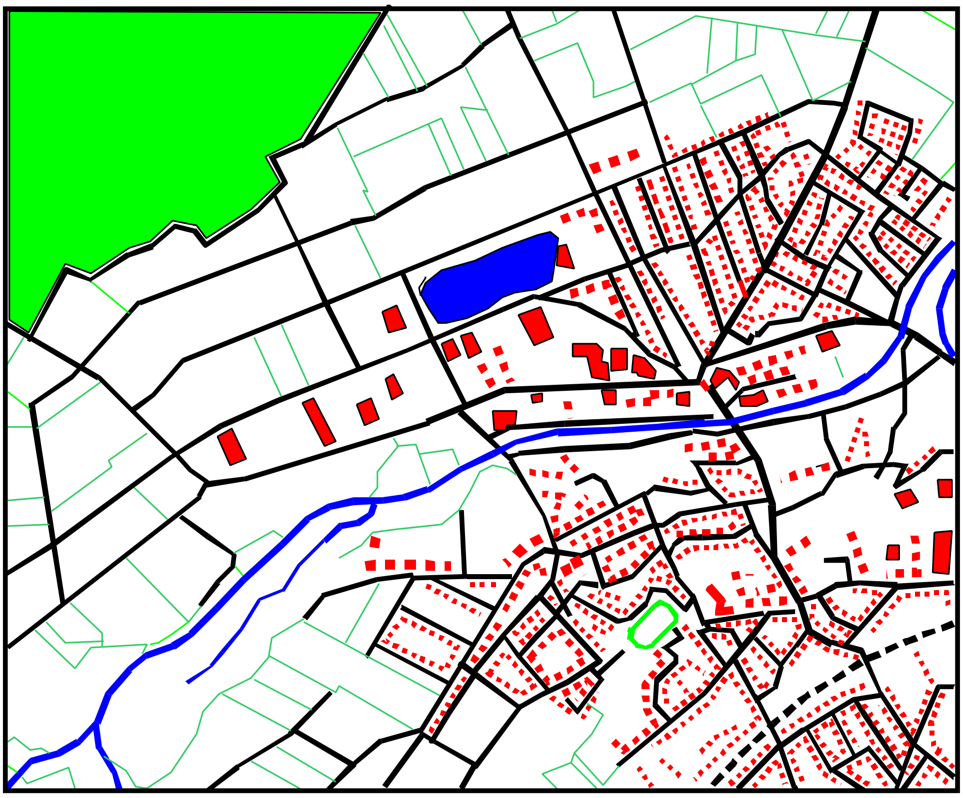


figure 5: area of Wunstorf mapped with compressed KVR1000-image

figure 6:

IRS-1C PAN part of Wunstorf

Figure 4 shows the result of the mapping with the different space images. The high altitude photo flight with the photo scale 1 : 120 000 is from 1976, by this reason some build up areas are missing and other parts are changed. The contents of the maps is also depending upon the operator, by this reason the KVR1000 images have been mapped twice (figure 5). In the second map there are much more details. Also the IRS-1C PAN-image part (figure 6) shows more details than included in the lower left map of figure 4:

4. Conclusion

The resolution and quality of the available space images has been improved and this will be continued also in the next years with the announced very high resolution commercial space system of the USA and the IRS-P4 Cartosat. Also SPOT goes to a higher resolution.

With images from the KVR1000 and the IRS-1C PAN today a mapping with satisfying results in the map scale 1 : 50 000 is possible. The achieved results are confirming the rule of thumb of a required ground resolution of 0.1 up to 0.2mm/lp or 0.05 up to 0.1mm pixel size in the map scale corresponding to 5 – 10m/lp or 2.5 – 5m pixel for the important map scale 1 : 50 000. Of course a field check is required because some details can be seen but not identified.

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