"MOMS 02 – Technical capabilities and possible applications to Mediterranean ecosystems"

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ABSTRACT

The MOMS 02, acronym for Modular Optoelectronic Multispectral Stereo Scanner, is a new experimental CCD-sensor system using the "pushbroom principle". It is able to acquire spectral data in 4 multispectral bands (Band1 440nm-505nm, Band2 530-575nm, Band3 645-680nm, Band 4 770-810nm) with a spatial resolution of 13.5m. The sensor is also equipped with 3 panchromatic bands (Band 5 4,5m spatial resolution, Bands 6 and 7 13.5m spatial resolution). Besides the high resolution of 4.5 meter the 3 bands offer because of their internal pitch a unique three-fold along track stereo capability. Simulations have been done to define the band location and to test the technical capabilities in comparison with other sensors. The results lead to the conclusion that the spatial, spectral and radiometric resolution combined with the new stereo capability will result in improvements to other remote sensing systems. Evaluation strategies for the acquired data are shown. When MOMS 02 will be placed on board of MIR-PRIRODA it will offer many new possiblities for applications.

1. INTRODUCTION

MOMS 02 (Modular Optoelectronic Multispectral/Stereo Scanner) is a CCD-sensor using the "pushbroom" scan principle (Meißner, 1982). As a logical consequence of successful MOMS 01 missions in 1983 and 1984 the new sensor MOMS 02 was mainly designed and built to fulfil the following scientific requirements:

- higher geometric resolution in comparison with existing systems
- along track stereo imagery in combination with the high resolution band or multispectral bands
- optimized layout of multispectral bands with narrow band width for various thematic applications

The system recently has been tested during the German D2-mission (25.04. – 06.05.1993).(Zilger *et al.*,1993)

2. TECHNICAL FEATURES

Designed to fulfil requirements of photogrammetric and thematic sciences this scanner is characterized by the following features:

1.1 Spectral capabilities

Based on a modular concept which is shown in figure 1 the sensor is equipped with 5 lenses. CCD-sensors are located in the focal plane of each lens. The central lens with a focal length of 660 mm enables the system to high resolution imagery. To achieve three-fold stereoscopic imagery two lenses with a focal length of 237.2 mm and pitches of +21.4°/-21.4° are added. Two other lenses with a focal length of 220 mm allow multispectral imaging in 4 different bands. Therefore two CCD-sensors with their corresponding filters are placed in the focal plane of each lens.

As a result of this configuration MOMS 02 can acquire images in 4 multispectral bands and 1 panchromatic band. The performance characteristics are described in **Table 1**. **Table 2** gives an overview of MOMS 02 band location in comparison with other sensors.

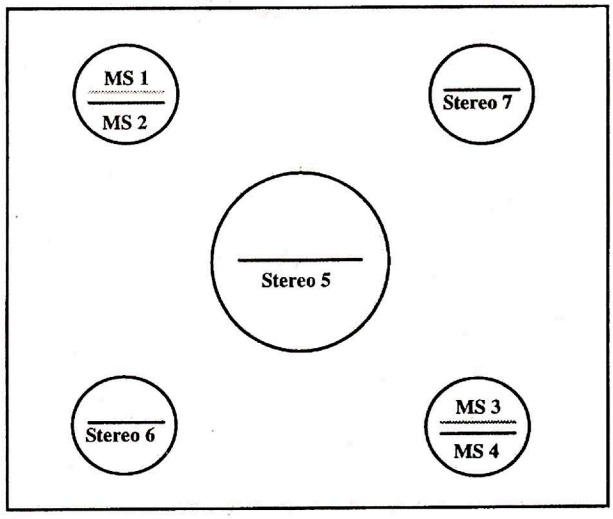

Figure 1 - Optical concept

Table 1 - MOMS 02 Performance characteristics

Channel	Mode	Orientation	Band Width	Ground Pixel
1	MS	Nadir	440-505mm	13.5 x 13.5m
2	MS	Nadir	530-575mm	13.5 x 13.5m
3	MS	Nadir	645-680mm	13.5 x 13.5m
4	MS	Nadir	770-810mm	13.5 x 13.5m
5	HR	Nadir	520-760mm	4.5 x 4.5m
6	Stereo	+21.4°	520-760mm	13.5 x 13.5m
7	Stereo	-21.4°	520-760mm	13.5 x 13.5m

(MS = Multispectral/ HR = High Resolution)

1.2 Spatial characteristics

Limited by the maximum data recording rate of the onboard magnetic tape (100 Mbit/sec.) it is not possible to operate all bands simultaneously. Operating modes were defined, taking the different scientific aims into consideration, as shown in table 3.

Table 3 - MOMS 02 Modes and swath widths

Mode	Bands	Swath Width
I	5a + 5b/6,7	37/40 km
II	1,2,3,4	78 km
III	3,4,6,7	78 km
IV	1,3,4,6	78 km
V	1,3,4,7	78 km
VI	2,3,4/5A	43/27 km
VII	1,3,4/5A	43/27 km

Swath width is determined depending on mode and D2-mission parameters.

Mission parameters:

Orbit inclination	28,5°
Nominal flight altitude	296 km
Necessary solar altitude	20°-70°

Figure 2 illustrates the imaging geometry and the different nominal swath widths.

Table 2 - MOMS 02 band location in comparison with other sensors (unit = micrometer)

		Band	TM	Band	MSS	Band	SPOT	Band	NOAA	Band	MOMS 01	Band	MOMS 02
	blue	1	0.45-0.52									1	0.44-0.505
visible	green	2	0.52-0.60	1	0.50-0.60	1	0.50-0.59					2	0.53-0.575
	red	3	0.63-0.69	2	0.60-0.70	2	0.61-0.68	1	0.58-0.68	1	0.575-0.625	3	0.645-0.68
	near	4	0.75-0.90	3	0.70-0.80	3	0.79-0.89					4	0.77-0.81
				4	0.80-1.10			2	0.725-1.10	2	0.825-0.975		
	middle	5	1.55-1.75										
infrared		7	2.08-2.35										
								3	3.55-3.93				
	thermal	6	10.40-12.505		10.40-12.60			4	10.3-11.3				
								5	11.5-12.5				
panchro-HR						P	0.51-0.73					HR	0.52-0.76
matic	Stereo											ST	0.52-0.76

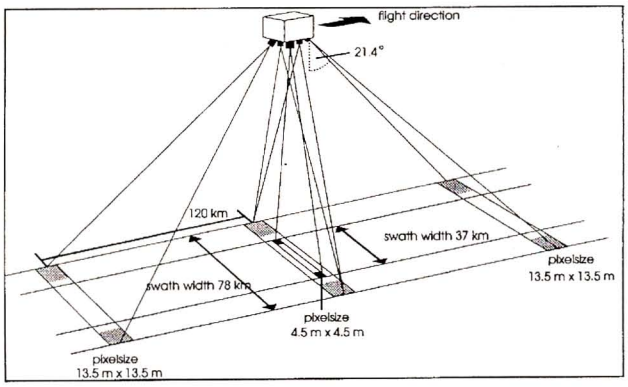

Figure 2 - MOMS 02 imaging geometry

Depending on sensor technique and mission parameters the pixel size on the ground is fixed.

Pixel size

Multispectral and Stereo	13,5 m
High resolution	4,5 m

Figure 3 shows the differences in ground pixel size between the main remote sensing systems.

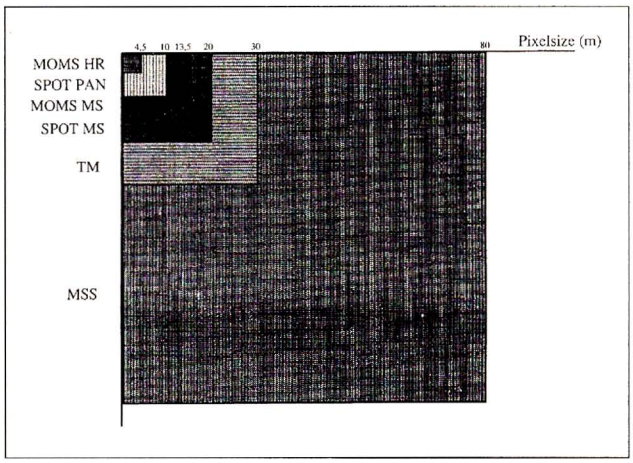

Figure 3 - Comparison of pixel sizes (MOMS 02, Spot, Landsat)

1.3 Radiometric characteristics

New CCD technology and optimized optics offer an overall radiometric range of 11,5 bits (2896 grey levels). Because of the limited data recording rate this range had to be reduced to 8 bits (256 grey levels). By introducing a "gain factor" it is possible to move an 8 bit "acquisition window" on the radiometric range of 11,5 bit according to the expected ground albedo and sun elevation (see **Figure 4**).

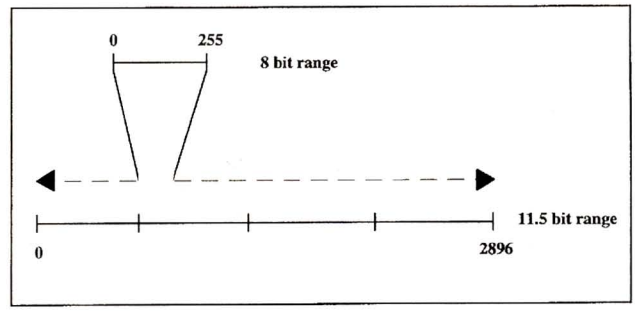

Figure 4 - Gain factor

1.4 Stereo characteristics

One of the most interesting new features is the unique MOMS 02 stereo imaging principle illustrated in **Figure 5**.

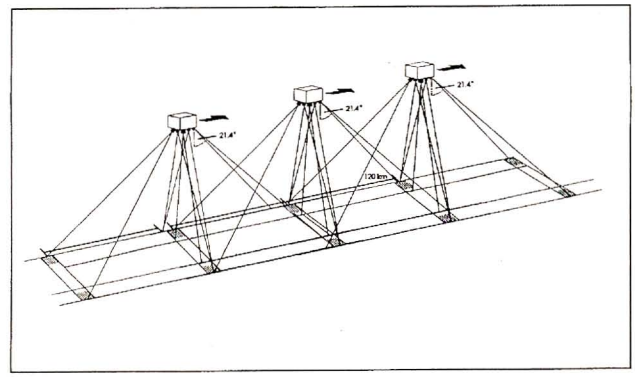

Figure 5 - MOMS 02 stereo configuration

The fact that locations on the track are recorded from three different viewing angles within 60 seconds allows stereoscopic processing. With additional information like flight– and camera parameters modern software is able to generate digital elevation models (DEM´s), important for accurate geometrical correction and accurate interpretation/classification in mountain ous areas. Contrary to SPOT the two images are recorded within seconds of each other so that effects resulting from different aquisition dates are avoided.

1.4 Data availability

Due to Space Shuttle flight parameters only areas between +28,5° and -28,5° latitude theoretically could be recorded during D2-mission. When the Shuttle passed test areas of main interest data was recorded on request from earth. Images will be available for the public after scientific evaluation by the science team. An overview of the recorded tracks is given in a catalogue. Also quicklooks will be available.

3. EVALUATION OF MOMS 02 DATA

In order to get best results the work on evaluation has been structured into thematic parts. Experienced scientists from german universities participate in the science team. **Figure 6** shows the structure and main aims of the team.

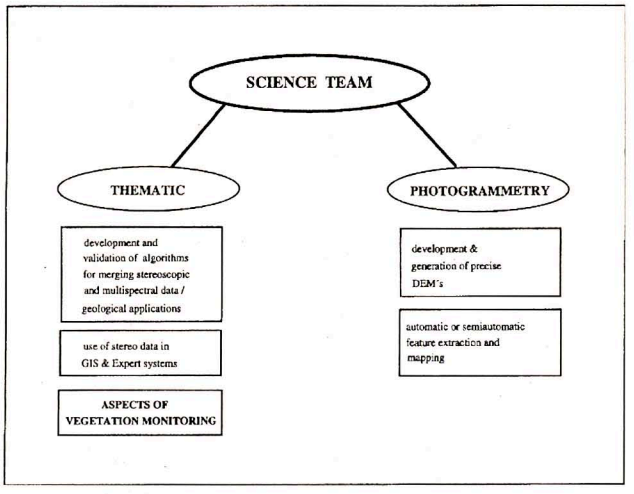

Figure 6 - Structure and aims of the science team

3.1 Work on aspects of vegetation monitoring

The work on aspects of vegetation monitoring has been structured into 3 parts.

I. Preparatory work for definition of sensor parameters

II. Research on spectral significance of vegetation formations in regard to interpretation and evaluation of MOMS 02 data.

III. Evaluation and verification of MOMS 02 data especially in regard to their potential for vegetation discrimination, land use mapping, monitoring and potential risk mapping.

So far members of the Institute for Landuse Planning and Nature Conservation have worked on parts I and II.

3.1.1 Simulation of MOMS 02 data

First simulations have been done to set up the band definition. (Kaufmann *et al.*,1988) In order to verify the advantages of MOMS 02 performance additional simulations were conducted by the thematic science teams. **Figure 7** gives an overview of the strategy.

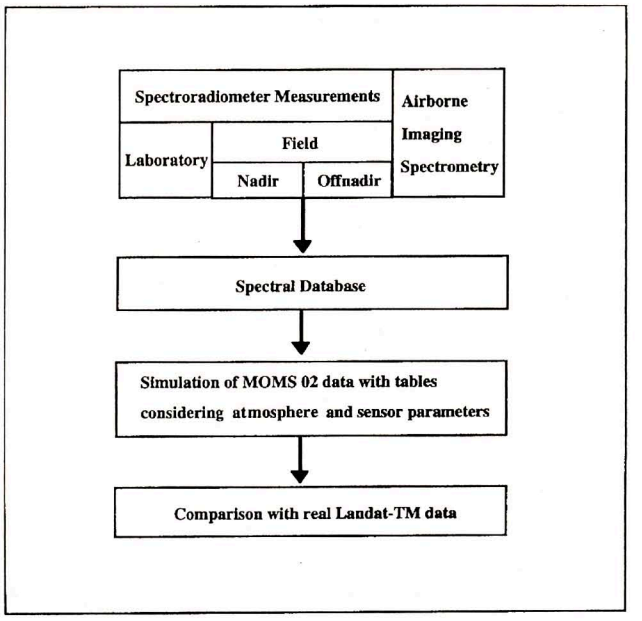

Figure 7 - Performance simulation strategy

Field spectroradiometer measurements have been done at 4 different test sites (Riftvalley, Ethiopia/ Garching, Germany/ Hildesheimer Börde, Germany/ München, Germany). The results (see **Figure 8**) showed, that the spectral characteristics of the same plant species are similar if the canopy is closed, the development stages are the same and the irradiation geometry is comparable (Bodechtel *et al.*,1991).

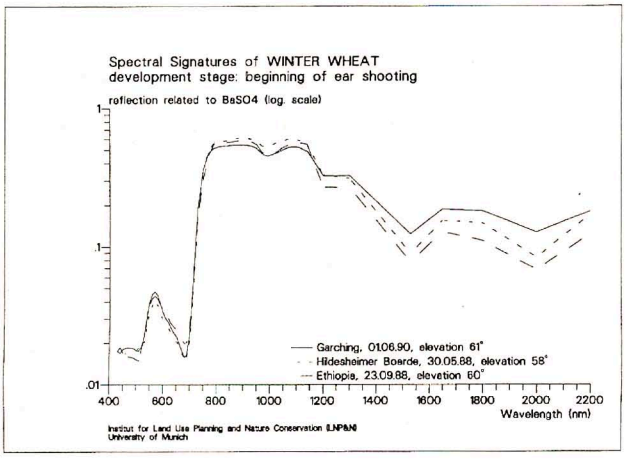

Figure 8 - Spectral data of 3 different testsites

Therefore, it is assumed, that in combination with atmospheric simulation models a comprehensive spectral database established in one area will help to check the spectral relationship of concurrent crop types at any other specified area and of any specified vegetation status (Bodechtel *et al.*, 1993).

Based on tables provided by the DLR (Richter, 1991) MOMS 02 DN-values have been calculated. These tables give DN-values for the different MOMS bands using athmospheric transmission model LOWTRAN 7 (Kneizys *et al.*, 1988) and the sensor parameters (Meissner, 1990).

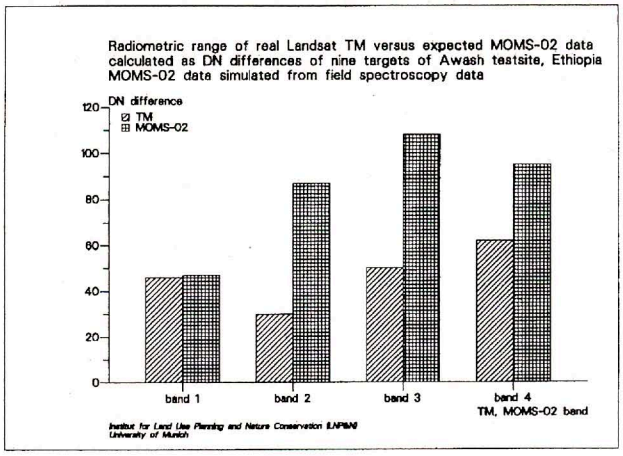

Figure 9 - DN difference TM-MOMS 02 of the same target

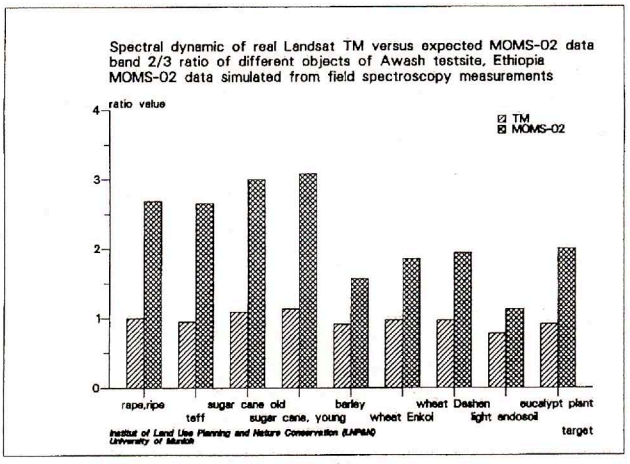

Figure 10 - Ratio-difference TM-MOMS 02 of the same target

The results, compared with DN-values and ratios of real TM-data for the same targets (see **Figure 9** and **Figure 10**), show the improvement of MOMS 02 data. (For more detailed results see Koch *et al.*, 1993)

3.1.2 Strategy for evaluation of MOMS 02 data

The first images radiometrically and system corrected will be available for the scientific teams in April 1994.The processing and analysis actions shown in **Figure 11** are planed to be done for selected test sites in Ethiopia.

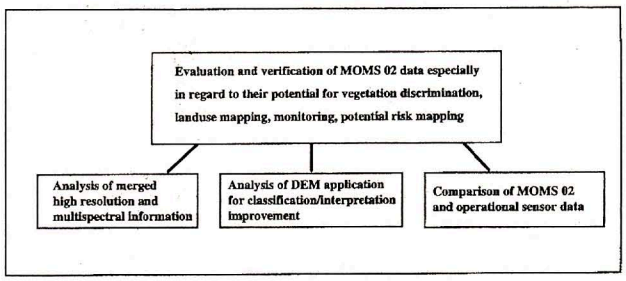

Figure 11 - Data evaluation strategy

The results will be verified by ground truth checks and already existing landuse maps.

4. MOMS 02 ON MIR-PRIRODA

MOMS 02 on board of the Space Shuttle during D2-mission was of experimental nature to test the technical performance. It is planned to place the sensor onboard of MIR , the russian space platform. The mission will last at least for one year and the data will be available for commercial use. The flight altitude is planned to be between 350 and 400 km. The orbit inclination is between +51.6° and -51.6° latitude. For 350 km flight altitude pixel size and swath width will be:

Table 4 - MOMS 02 on MIR parameters

	Pixel size	Swath width
multispectral	15,9 m	92 km
high resolution	5,3 m	44 km
stereo	15,9 m	88 km

3 different modes are planned:

Mode 1	1/2/3/4	multispectral
Mode 2	5a/6/7	stereo
Mode 3	5a/1/2/3	HR + MS

A repetition rate between 2-7 days can be expected. The data has to be recorded on request.

5. POSSIBLE APPLICATIONS TO MEDITERRANEAN ECOSYSTEMS

Mediterranean ecosystems are characterized by a unique richness of different plant communities and plants. This variability has been enriched by human degradation and landuse. Despite optimum adaptation to site and climate

these ecosystems are unstable and sensitive to human influence. Therefore accurate analysis and mapping of of these ecosystems as regards their structure, distribution, dynamic, and changes are very important to develop new landuse management strategies.

Due to the new technical capabilities of MOMS 02 many new applications can be expected, *e.g.*:

- stereo capability allows DEM generation for:
  - erosion risk mapping
  - classification improvement in mountaineous areas
  - geometrical correction improvement in mountaineous areas
  - road planning in mountainous areas
  - harvesting management in mountainous areas
- improved spatial resolution in panchromatic and multispectral bands allows:
  - better structural analysis
  - more accurate mapping at scales up to 1:25000
- improved spectral and radiometric resolution allow:
  - better spectral discrimination of different vegetation formations

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