

## Thematic Mapping by Satellite – A new tool for planning and management

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**ABSTRACT:** The new generation of "high-resolution" remote sensing satellites will increase the number of applications drastically. It is believed that the imagery of these new satellite systems will play a substantial role in the planning and management practices of land and water. Even in countries where a well-developed structure for geo-data processing exists such as the Netherlands, satellite remote sensing forms an important additional source of information in planning and management. This latter statement is also supported by the encouraging results of the case study presented in this article. The objective of the study was to evaluate the possibilities of the new satellite imagery and to present the obtained information in a way accessible to planners, etc. Therefore the concept of the "Satellite Thematic Map" was adopted as a user-friendly endproduct useful for a large user community. In the article, characteristics of the Satellite Thematic Map for the "Kromme Rijn" Area in the Netherlands are discussed.

**RESUME:** La génération nouvelle des satellites de télédétection à "haute résolution" augmente le nombre d'applications de façon dramatique. Ces systèmes spatiaux joueront un rôle substantielle dans les techniques de planification et aménagement des ressources naturelles. Aussi bien dans les pays qui disposent d'une infrastructure de géodésie la télédétection par satellite est une source d'information importante. Cette conclusion est supportée par les résultats encourageantes de l'étude présente dans cet article. L'objectif de l'étude était d'évaluer les possibilités des images satellites nouvelles et de présenter l'information obtenue d'une façon accessible pour une grande communauté de planificateurs. Avec cette objective le concept du Carte Thematique par Satellite est élaboré et appliqué pour une zone rurale au Pays-Bas.

### 1 INTRODUCTION

With The launch of Landsat-4 in June 1982 a new era of satellite remote sensing started. On board of this satellite a new sensor system was installed, the Thematic Mapper (TM) next to the conventional Multi Spectral Scanner (MSS) sensor system increasing the spatial resolution of 80m\*80m to 30m\*30m. Recently on February 22, 1986 the French/Swedish SPOT-1 (Système Probatoire d'Observation de la Terre) remote sensing satellite was launched increasing the spatial resolution to 10m\*10m. This development required an evaluation of the possibilities for application of this new information stream in planning and management of the land and water resources in the Netherlands. Use was made of Thematic Mapper imagery because at the time the study was carried out SPOT-1 was not launched. Future research will concentrate on the evaluation of SPOT imagery and on the comparison of Thematic Mapper with SPOT imagery.

### 2 OBJECTIVES

Before the launch of Landsat-4 with onboard the Thematic Mapper sensor system the use of satellite remote sensing for land applications in the Netherlands were very limited. This was caused by the restricted spatial resolution of the conventional sensor systems in use of which the Multi Spectral Scanner (MSS) onboard the Landsat series of satellites with 80m\*80m is best known. This situation is expected to change with the use of the high resolution sensors. The higher resolution meets more closely the detail of information needed in planning and management in the Netherlands. DHV Consulting Engineers carried out a case study to evaluate these possibilities of the new imagery and to establish the contribution which can be made to the already existing well-developed information structure present in the Netherlands. A second objective of the study became to develop a method to present the satellite

information in a way accessible to a large community of planners, who are not acquainted to the use of remote sensing data.

### 3 METHODS

For the project use was made of Thematic Mapper imagery of August 22, 1984 and January 23, 1983 of an area in the central part of the Netherlands, the "Kromme Rijn" Area. This region was chosen since it contains different land use types, small sized (<1.0 ha) agricultural fields and many small-scaled landscape elements. The project was carried out in two phases; the first phase was a qualitative evaluation of the thematic content of the imagery, the second phase concerned a more quantitative approach towards the preparation of the thematic content in the imagery onto a map. This led to the development of the "Satellite Thematic Map". The imagery was processed on the RESEDA image processing system (DIPIX) of the National Aerial and Space Laboratory, NLR, The Netherlands. Contact prints for further analysis were made of false color and especially 4,5,3 channel combination composites. During the second phase as a test experiment a thematic map was prepared on which the land use changes were given in comparing to the most recent topographical map of that area. The topographical map used was of 1985 but based on aerial photography of 1980. Therefore land use changes in a 4 year period were presented on the thematic map.

#### 3.1 Sensor characteristics

Characteristics of the Landsat Thematic Mapper and Spot system are presented in table 1. The sensors onboard the SPOT-1 satellite record in two different modes; one 10m\*10m spatial resolution panchromatic mode and a multispectral mode with a 20m\*20m spatial resolution. A new feature of SPOT is its off-nadir

pointing capability which result in 1) higher temporal coverage and 2) stereoscopic image recording. The thermal channel of the Thematic Mapper has a spatial resolution of 120m\*120m in stead of the 30m\*30m of the rest of the channels. In comparing the Thematic Mapper and the SPOT characteristics it may be expected in general that the Thematic Mapper is better equipped for thematic information extraction and SPOT is better suited for cartographic applications because of its stereoscopic capability and the 10m\*10m resolution panchromatic recording mode.

Table 1. Sensor characteristics of Landsat-4 and 5 Thematic Mapper and Spot system.

Sensor:	TM	SPOT
Launch	06/1982	22/02/86
resolution(m)	30*30	10*10 20*20
spectral channels(nm)		(MSS) (PA)
1	450- 520	500-590 510-730
2	520- 600	600-680
3	630- 690	790-890
4	760- 900	
5	1550- 1750	
6	2080- 2350	
7	10.3- 12.5 (um)	
scene coverage(km)	185*185	60*(60 to 85)
temporal resolution	16 days period	3-5 times/26 days

### 3.2 Thematic Mapper geometric accuracy

Next to the characteristics of the satellite system the accuracy of the registration of satellite imagery to maps plays an important role. The geodetic accuracy or scene-to-map registration accuracy is dependent on the accuracy with which the Ground Control Points (GCP's) can be indicated on the imagery and on the map, the topography of the area concerned and the algorithms used for the registration. For favorable conditions, the rectified TM data can meet NMAS (US cartographic standard) for map products at scales to 1:24.000 but typical GCP configurations and average terrain conditions will conform to standards for 1:50.000 to 1:100.000 scale maps (R.Welch, 1985). It is expected that in general these accuracies will be higher in the Netherlands because of better opportunities for GCP location and because the error associated with relief displacement can be neglected. Therefore it is expected that a 1:25.000 scale accuracy can be achieved.

### 3.3 Discussion with planners

In 1984 and 1985 DHV organized a series of meetings with central, provincial and local authorities occupied with the planning and management of land and water. During these meetings an inventory was made of the needs of satellite imagery derived information. The meetings lead to the following conclusions:

- the detail on the high resolution satellite imagery makes it a valuable source of many relevant information
- this information can add in a cost-effective way to many planning and management applications
- the information present in the satellite imagery is not accessible to most of the planners, because they are not familiar with the interpretation and techniques involved in using satellite imagery.

These conclusions formed the reason for DHV Consulting Engineers to develop techniques to present the satellite derived information in a more user-friendly way. This lead to the development of the Satellite Thematic Map concept.

## 4 RESULTS

### 4.1 Thematic content of the Thematic Mapper imagery of the "Kromme Rijn" Area

The information content of the imagery was evaluated by comparing the imagery with the topographic map 1:25.000 and vegetation/land use maps of the area. It was shown that the spatial resolution of the Thematic Mapper imagery was sufficient to discriminate between individual fields. This was also confirmed during a field check. The color classes which could be discerned on the Thematic Mapper imagery showed a very good resemblance to the land use classes of the topographic map.

In general grassland, forest (coniferous, deciduous and mixed), agricultural fields, orchards, cities, villages and surfacewaters could be made from the imagery. In addition some refinements to the legend of the topographic map could be discriminate on the imagery. A differentiation between mais and fallow land, old and young apple orchards and management practices, for example the clearing and cutting of forest areas could be established. Also small linear tree-elements with up to a sub-pixel dimension could be distinguished. However the possibilities for the inventory of very small (linear) features with Thematic Mapper imagery seems restricted and must be evaluated for every case in detail.

### 4.2 Combination of satellite imagery with the topographic map

However to actually derive a land use map from the satellite imagery the interpretation of a especially forest, mais and orchards was difficult. By overlaying the satellite imagery with the topographical map this problem could be solved and an high accuracy interpretation became possible.

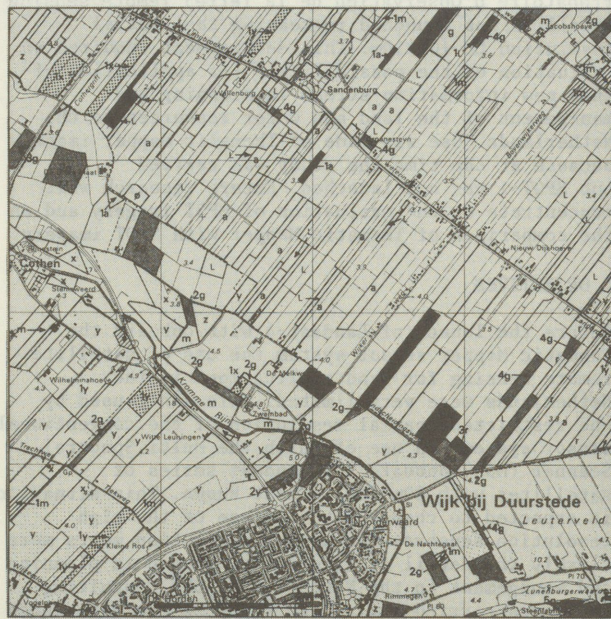


Figure 1. Satellite Thematic Map of the "Kromme Rijn" Area; scale 1:25.000.

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#### 4.3 The Satellite Thematic Map

As a test a land use change map of the "Kromme Rijn" Area based on satellite imagery was made according to the above mentioned method leading towards the "Satellite Thematic Map" of the "Kromme Rijn" Area. After the interpretation a final field check followed for a general control and to solve the last interpretation problems.

A part of the final map is presented in figure 1. The topographic map 1:25.000 serves as a background. The map shows the changes in land use from 1980 to august 1984. For this, use was made of the most recent topographic map of 1985 which is based on aerial photography of 1980 and a Thematic Mapper image of august 22, 1984. The dotted and the hatched areas on the map indicate a change in land use which occurred between 1980 and 1984, while the symbols placed within the blank fields indicate a refinement in the land use in comparing to the Topographic Map.

#### 5 CONCLUSIONS AND DISCUSSION

From the above it can be concluded that satellite imagery provides a base for updating land use maps and actual land use mapping up to a scale of 1:25.000 by using Thematic Mapper imagery. Interpretation accuracy can be raised considerably by overlaying the satellite imagery with existing maps such as the topographic map. The Satellite Thematic Map provides a framework to present the information on satellite imagery in a user-friendly way which is accessible to a large user community. The Satellite Thematic Map forms a flexible way of presenting thematic information extracted from satellite imagery. The presentation of land use change was only one example. For instance mapping of natural vegetation, vitality of forest, city growth and surface water are other applications. An other aspect of the Satellite Thematic Map concept is that in digital form, either a raster or a vector format, this kind of maps form a very suitable input for Geographical Information and Land Information Systems. One example is the combination of cadastral maps, with ownership and tax registrations and with actual land use information derived from satellite data. The panchromatic imagery of SPOT will enable many new applications for instance in town mapping and planning and more detailed inventories in rural regions for which the Satellite Thematic Map concept can form a useful tool for presentation. Therefore it is believed that the new generation of "high-resolution" remote sensing satellites will increase the number of applications drastically and will play a substantial role in the planning and management practices of land and water in the Netherlands and consequently in many of the industrialized and developing countries.

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