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ABSTRACT
Effective global forest monitoring can be achieved by means of Earth Observation techniques. The most promising technique in this respect is the synthetic aperture radar (SAR) technique. Due to the high percentage of cloud cover in tropical and temperate regions SAR offers excellent opportunities to monitor the forests. Requirement studies in the past have discovered that requirements from users focus on five aspects: the availability of data, the accessibility of data, the affordability of data, the timeliness of data and thematic aspects. On the basis of these requirements aspects a concept was developed which emphasises an end-to-end small space mission approach. This approach is characterised by a complete integration of the ground- and space segment, rather than treating them seperately. The concept is based on two key-elements: decentralised, low-cost reception and processing capabilities and a low-frequency SAR. This paper presents the initial concept, and its elements, based on work performed within the National Space Technology Programme.

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A CONCEPT FOR A LOW-COST DEDICATED INFRASTRUCTURE FOR THE MONITORING OF TROPICAL FORESTS

by

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A CONCEPT FOR A LOW-COST DEDICATED INFRASTRUCTURE FOR THE MONITORING OF TROPICAL FORESTS

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ABSTRACT

Effective global forest monitoring can be achieved by means of Earth Observation techniques. The most promising technique in this respect is the synthetic aperture radar (SAR) technique. Due to the high percentage of cloud cover in tropical and temperate regions SAR offers excellent opportunities to monitor the forests. Requirement studies in the past have discovered that requirements from users focus on five aspects: the availability of data, the accessibility of data, the affordability of data, the timeliness of data and thematic aspects. On the basis of these requirement aspects a concept was developed which emphasises an end-to-end small space mission approach. This approach is characterised by a complete integration of the ground- and space segment, rather than treating them separately. The concept is based on two key-elements: decentralised, low-cost reception and processing capabilities and a low-frequency SAR. This paper presents the initial concept, and its elements, based on work performed within the National Space Technology Programme.

1. INTRODUCTION

There is a growing need for timely and reliable information on forest cover and the extent and rate of forest degradation in tropical and temperate regions. Remote sensing is a source of information reliable to assess forest cover changes on an operational and sustainable basis. Effective global forest monitoring is practically only possible using radar techniques due to the high percentage of cloud cover in a significant number of tropical countries. Based on requirement studies [1,2,3,4] it was concluded that in order to fulfil the operational requirements of local forest managers a dedicated solution had to be offered. Therefore, taking into account some of the trends in space, and taking into account [5] a global forest monitoring concept was described. This conceptual work [6] was carried under the framework of the National Space Technology Programme, managed by the Netherlands Agency for Aerospace Programmes.

2. USER REQUIREMENTS

In [3] a detailed study into user requirements is presented. Here, requirements from users mainly focus on four general items, the availability of earth observation data for the area of interest, the accessibility of data for the area of interest, the affordability of data, and the timeliness of data. These general items are a prequisite for any successful operational application. After solving these general items specific forest information requirements were mentioned. Basically, this latter group of requirements is concerned with: avoiding cloud cover, scale of operations (preferably 1:250.000), temporal frequency (every 2-3 months) and specific forest monitoring information like forest/non-forest identification, burned area identification, logged area identification (either selective logging, slash & burn or clear cuts), % vegetation cover, biomass estimates, timber volume estimates and human impacts identification.

The Netherlands Working Group Remote Sensing for Forests (ROBO), [7,8], is looking into the application of Earth Observation techniques for foresty purposes. As such members of the ROBO are studying the applicability of radar techniques for forest monitoring. An important dataset in those studies is generated by JPL's AIRSAR system [9] during airborne campaigns in the Netherlands and South America. Results from those studies identify the high potential of low-frequency SAR for forest monitoring [10,11,12]. The requirements of the users together with the results of studies carried out formed the basis to develop a concept for operational forest monitoring.

3. THE CONCEPT

In the development of a concept, [2] identifies three basic elements necessary to come to an operational forest monitoring system. First, the development of the required methodology. Second, the system design and third, the operations. Each of these elements is represented by different groups i.e. the researchers, the system designers and developers and the operational users. The latter group is by far the most important group as they drive the system design and development which in itself drives the development of methodology.

In the development of the concept for a low-cost dedicated infrastructure for the global monitoring of forests the basic idea is to integrate the space- and ground segment with each other, rather than to treat them separately. As the ground segment, obviously, is the closest to the user, the most demanding requirements originate from the ground segment. To fulfil the general requirements, as noted in section 2, the following concept, based on two major elements, was developed. The first major element is the decentralised, low-cost reception and processing capability. This will solve the availability-, accessibility-, affordability and timeliness-items. The second major element is the use of a low-frequency SAR based on some of the small mission principles [13]. This will solve the specific forest information requirements and the affordability-item, as the data will be available for free.

3.1. The Ground Segment

Decentralised, low-cost reception and processing capability is the major element in the ground segment. The fact that there already exist a decentralised, low-cost reception infrastructure, available to a large group of users, i.e. the NOAA-AVHRR infrastructure was an important element in the development of the concept. In principle, users who have available such low-cost NOAA-AVHRR-HRPT receivers will only have to do small investments in upgrading their system to receive the low-frequency SAR data. By having the capacity to receive high temporal, low resolution NOAA-AVHRR data together with the low-frequency SAR data synergy between optical and radar observations can be achieved. Three other aspects, besides low-cost, play a major role in the conceptual development of the ground segment (the receiving station): serviceability, independency and user friendliness. This has resulted in the conceptual development of a decentralised, PC-based receiving station based on the NOAA-AVHHRR-HRPT infrastructure.

Current PC-based receiving stations can take approximately 665 kbits/sec worth of data and this value is the major driver of all developments. However, it is likely that on-going development work will lead to data rates in the order of 100 Mbits/sec.

3.2. The Space Segment

Low-frequency SAR, combined with adhering to some of the small space mission principles, is the major element in the space segment. By taking the specific forest information requirements together with the current data rate as driver for the space segment conceptual development, the concept of a small autonomous satellite with a single payload (a low-frequency SAR) was developed. Currently the technological possibilities of two SAR-concepts are studied where one such concept is based on being compatible with the NOAA-AVHRR-HRPT infrastructure but with a low radiometric resolution. The other concept is looking into the possibility of having a high radiometric resolution but with a higher data rate than currently possible. In general the baseline in both concepts is a dedicated P-band SAR (0.435 GHz), although L-band SAR is considered a reasonable alternative, operating in a circular polarisation mode on a dedicated satellite of approximately 400 kg launch mass. A small-sat approach is highly desirable to achieve an operational situation within a reasonable time schedule and to keep system cost low.

4. CONCLUDING REMARKS

The presented concept meets the requirements of users. These requirements reflect mainly general items such as availability, accessibility, affordability, and timeliness of the earth observation data and reflect specific forest information needs.

A decentralised low-cost, reception and processing capability is one of the major elements of the concepts. Within the technological boundaries it is possible to receive

P-band SAR data on a PC using a data rate of 665 kbits/sec.

A dedicated satellite with a low-frequency SAR can perform continuously surveying at moderate resolution. Such satellite should be put in a sun-synchronous dawn-dusk orbit. However, some critical issues need to be examined in detail.

The selection of the SAR frequency is still under consideration. Preliminary studies suggest the use of a P-band SAR. However, L-band is considered a reasonable alternative which offers some technological advantages over P-band SAR. To derive the specific forest information P-band may, however, offer advantages over L-band SAR.

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