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The Operational Continuation of the EU Project Monitoring Agriculture with Remote Sensing (MARS) - Should DMI be involved?

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1. Summary.

The primary objective of MARS is to provide the decision makers in the European commission and EUROSTAT with improved agricultural information and yield forecasts but also to increase the use of remote sensing products in agricultural applications on an European scale.

After 10 years of organising and execution of the MARS project the Joint Research Centre (JRC) contacted EUMETNET[1] in the beginning of 1998 to investigate if EUMETNET could be an appropriate framework for the operational continuation of the MARS activities. It was suggested that the continuation should be carried out by the Space Application Institute (SAI) at JRC and one or more National Meteorological Services (NMS) but not with direct EUMETNET involvement. As a consequence the Danish Meteorological Institute (DMI) decided to investigate the possibilities for participating in the continuation of MARS.

The steering and operation of the project has been done from JRC/SAI under mainly 4 scientific and operational activities which include: (1) anti-fraud measures controlled and managed using remote sensing, including measures related to quality checks, tests and further developments of evaluation methods, land parcel identification systems and collection of production statistics of vineyards and olive trees, as well as support to the management of agri-environmental subsidies (2) crop and yield monitoring with agro-meteorological models and low resolution remote sensing methods and area estimates using high resolution data combined with ground surveys (3) specific surveys of area-frame sampling techniques to provide rapid and specific information needed for the definition or reform of agricultural policies (4) following technological developments in new sensors and methods, precision monitoring techniques and alternative data collection and processing techniques for large-scale agricultural applications.

DMI focused in particular on activity 2 which includes crop yield modelling and remote sensing monitoring of crop state using data already in available at DMI. The operational Crop Growth Model (CGMS) developed during the MARS project is operating on a European scale. However, adaptation of the CGMS model on local or regional scales has been carried out in some European countries both inside and outside the EU. A similar adaptation was considered at DMI using the experiences gained by these countries from scaling down the CGMS to the scale of individual countries and from utilisation of the CGMS products. Also the use of remote sensing data for crop state monitoring using software, data and methods from the MARS project was considered.

The evaluation of the MARS project after 10 years of operation was somewhat negative with respect to the crop yield and forecast activities. There was a general tendancy to judge the results and products to be dissapointing. Even though the project had been succesful on several points especially providing developing countries with expertise and tools for obtaining agricultural information, the fusion of models and remote sensing data and the use of remote sensing data in general were considdered insufficient.

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[1] *The Network of European Meteorological Services.*

The provisional extension of the MARS project (1999-2003) reflects this critisism raised against the project results. It has in the extended period become an explicit clause to base several of the activities on an increased use of remote sensing data and methods.

The investigations at DMI concerning the potential participation has reached the overall conclusion that it is not feasible or desirable for DMI to participate in the operational continuation of MARS. It must be emphasised that this conclusion is based only on the prior information notice about the invitation to tender and it therefore not impossible that full information about the invitation to tender may reveal new interesting information which to affect this conclusion.

The major points that underlies the conclusion is: it seems as if no requirements for MARS or MARS-like products were expressed by potential Danish users. A MARS related product development and potential enlargement of DMIs user base consequently seems unrealistic. Furthermore, it has been impossible, based on the available facts, to estimate to which extent DMI could profit economically from participating the operational continuation of MARS. It could be argued that algorithms and software developed with MARS, and potentially open for non-commercial use, may be of interest for DMI. However, in principle DMI could have access to both algorithms and software without being involved in MARS. This is indeed the case in countries which have decided to adapt the crop growth model. It is also anticipated that an operational responsibility will not improve DMIs chances of being involved in research programmes with JRC/SAI. To the authors there are therefore, based on the available facts, no obvious reasons for DMI to be operational responsible in relation to MARS. On the other hand it is important to stress that talks with other members of the EUMETSAT ad-hoc group, JRC/SAI and relevant Danish institutions have revealed a potential for submittal of joint research proposals related to the MARS programme. This has already been manifested through successful proposals submitted to the EU 5th Framework Programme. Indeed it may be expected that this joint research effort may have a positive impact on DMIs ability to influence the future use of numerical prediction models and remote sensing data in an agricultural context at the EU level.

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2. Terms of Reference.

The EU project Monitoring Agriculture with Remote Sensing (MARS) has been developing since its start in 1988. MARS has, until now, been organised and executed by the Space Application Institute at the European Union Joint Research Centre in Italy (JRC). However, components of MARS, notably the crop yield prediction, are now put into operational mode. As the JRC is primarily a research unit the question has consequently been raised by the Commission if public institutions in one or more of the member states should take over the operational responsibility of MARS.

The JRC contacted EUMETNET[2] in the beginning of 1998 to investigate if EUMETNET could be an appropriate framework for the operational continuation of the MARS activities. It was suggested that the continuation should be carried out by the Space Application Institute (SAI) at JRC and one or more National Meteorological Services (NMS).

The Danish Meteorological Institute (DMI) also decided to investigate the possible modes of participation in the operational continuation of MARS. The objective of this report is therefore:

- To give a general overview of MARS and its components.
- To analyse if DMI should take part in the operational continuation of MARS.
- To analyse if DMI and other Danish institutions, notably the Danish Agricultural Research Centre, should contribute to the development of MARS.

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[2] *The Network of European Meteorological Services.*

3. Introduction.

Through the 1980'es the agricultural community in EU was unbalanced with the market they were a part of, subsidising and custom barriers contributed significantly to the economy and the steering of the market. Planning, reforms and re-evaluation of the agricultural policy in EU were consequently necessary. It was acknowledged that to make efficient planning, a high information level was needed among the decision makers and a high information level was one of the important arguments for launching the MARS project in 1988.

The overall objective of the MARS project has been to extend the use of remote sensing within EU into operational products, monitoring agriculture and to provide useful information on crop state and issue yield forecasts in order to plan the market and to prevent oversupply of certain products. The data are collected from a continuous supply of measurements both remote sensing and point measurements, and the project as a whole is operating on scales from days to years. MARS has been running since 1988, certain parts of the project has recently been extended for additional 5 years under restricted conditions. The two main users of the information created under MARS are Directorate General VI (DG VI)[3] and EUROSTAT[4] The latter provide: the quantitative estimation of the areas occupied by the various crops in a given region or country; the area-wise monitoring of vegetation and crop state; the timely forecasting of mean crop yields at the level of the EU; the rapid and timely estimation, at EU level, of the total production of the most economically important crops. These two bodies are organisations integrated in the decision making process.

The MARS project, has operationally been implemented on several aspects of agricultural monitoring and statistics. Mostly research and development work in the project is delegated to private companies, national institutes and Universities. Among these agents, the NMS play an important role collecting and processing data. Even though the DMI on several points is able, the Institute has so far not been directly involved in the project.

This report describes in general terms the MARS project and analyses the possibilities for DMI to participate in the project in relation to
- Operational responsibility.
- Research and development.
- Data provider.

The objectives of the MARS Project are threefold (se also: www.ais.sai.jrc.it):
- Improve agricultural statistics through the use of remote sensing techniques, being handled by the MARS-STAT sector.
- Use remote sensing and related techniques to assist the implementation of the Common Agricultural Policy (CAP), of which the MARS-CAP sector is in charge. The MARS-CAP sector involves activities related to crop identification by satellite remote sensing as well as activities with a broader scope such as: the assessment of the precision and reliability of plot location and limits, the conceptual development of Integrated Administration and Control Systems.

[3] *DG VI: (See section 4.1)*
[4] *EUROSTAT: European Statistical Office*

- Support the transfer of methods to other geographical regions outside the EU and the adaptation of those methods to new themes. This is the responsibility of the MARS Geographic Extensions sector.

This report will not distinguish between the two terms STAT and CAP but describe the MARS project as a whole with focus on the most relevant applications for DMI.

3.1 Report organisation

The report is divided into 3 main chapters. Chapter 4 is describing and analysing the MARS project. This chapter has been prepared using the availabe literature published on the MARS project and the participation in the 10 year anerversary conference. The chapter is focusing on local implementation and subjects with relevance for DMI. Chapter 5 discusses the potential DMI participation in relevant parts of the project. The Danish Agricultural Research Centre, Department of Agricultural Systems (DIAS/DAS) at Research Centre Foulum is also a potential Danish partner in the project, who has earlier done work in MARS. Chapter 5 also describes the potential for a joint, DMI and DIAS/DAS participation in the MARS project. This chapter has been prepared through meetings between DIAS/DAS, DMI and relevant authorities in the Ministry of Food and Agriculture and the Statistics Denmark (see also 7.3). Chapter 6 concludes with recommendations for potential future involvement in MARS.

4. The MARS programme

4.1 Background

The formulation of the MARS project was the result of co-operation between DG VI and EUROSTAT. The emerging possibilities for utilisation of remote sensing in crop monitoring and environmental observation with respect to agriculture lead to the formulation of the MARS project in 1988. The 10 year project was not intended to involve additional research, but should integrate the existing and already operational methods and available data for use over long and continuous periods on the scale of EU. The chosen satellite data types were from the beginning selected for their granted continuity and the scientific methods were well tested before implementation.

Information on the geographical distribution of agronomic land use in EU and forecasting of agricultural production is important for planning and reforming the agricultural production and community in the European union. Since it has for some time been possible to retrieve reliable information on agricultural parameters of interest to EU using visual and infrared remote sensing methods, at least on a regional scale, the actual motive for initialising the MARS project was to utilise remote sensing for agricultural monitoring extended to a European scale. This was naturally first of all because of the interesting outcome of these measurements, but also to support the European application of agricultural remote sensing expertise. Heath (1993) mentions in particular 3 issues where the MARS project is able to provide improved information: 1) supplying objective information on land use reducing bureaucracy and individual interpretation in registration 2) providing both large scale and detailed information on crop state and land use for more efficient local and regional agricultural planning 3) the potential for providing low cost and fast information.

4.2 Organisation

The steering and organising of the MARS project is carried out by the JRC/SAI under the European Commission. SAI. The primary mission of SAI is to develop and promote the use of space derived data in the service of EU policies, especially those relating to agriculture, fisheries, transport, and anti-fraud. SAI also seeks to make the best use of information from space systems, to maximise the return from European investments in space and to help the Union reinforce its role in international action on the environment and sustainable development. The Agriculture and regional information systems sub-group, organising MARS, under SAI is lead by Jean Meyer-Roux (I-1, 1999).
In addition to the steering group at SAI there are two scientific support groups; 'SuGrAm[5]' and 'Soils and GIS[6]' (Burrill, 1993). The functions of these groups are only co-ordination and administration, and the intention was not that any development or scientific work should be done by the groups within the project commission. The tasks concerning: data collection,

[5] *The Support Group of Agro-meteorology (SuGrAm), co-ordinated by the World Meteorological Organisation.*
[6] *Their task has been focused on developing a soils database, the work is done in collaboration with the French 'Institut National de le Recherche Agronomique' (INRA).*

scientific work, the operation of the data processing algorithms and numerical models is distributed to the external participants such as research institutions and operational facilities e.g. national meteorological institutes with the expertise in Europe.

The two support groups (‘SuGrAm’ and ‘Soils and GIS’) has organised different activities of the MARS project. The SuGrAm group has advised the project on the co-ordination and establishment of agro-meteorological models for crop state monitoring and yield forecasting. This group consists of agro-meteorologists with expertise in agro-meteorological modelling. One of the main tasks for this group has been to implement and integrate agro-meteorological models in Europe overcoming the differences there are between data formats. The aim has been to evaluate the model results and recommend certain areas and regions for further study. The task of the ‘Soils and GIS’ group has been to develop a European soils database. The aim with the data base is 1) to develop a data product suitable for agro-meteological modelling 2) for environmental planning and application on an European scale. Creating the database the work has been focused on the harmonisation of the national soil mapping conventions to ensure that the database is consistent (Burrill, 1993).

4.2.1 Participants and schedule

The MARS project was from the beginning divided into two five year phases, phase 1 and 2. Phase one (1988-1993) focused on the co-ordination and implementation of data and model inputs from more than 100 institutions in 17 different European countries (See appendix 7.3). The data were, by the different institutions, evaluated for use on an European or regional scale. The programme work was based on existing knowledge and the activities and work were extensively distributed to the institutions with the expertise participating the project. Phase two (1993-1998) evaluated the results and products developed during the first phase, refining the methods and products. The products were tested operationally and put in real time operation if successful. Phase 3 has recently been approved which continues the operational activities in MARS.

4.2.2 Activities

The MARS project is structured along the following activities:

Anti-fraud measures: Tasks include the management of the control with remote sensing program, and related quality checks, tests and further developments of evaluation methods, land parcel identification systems and collection of production statistics of vineyards and olive trees, as well as support to the management of agri-environmental subsidies.

Crop and yield monitoring: crop yield monitoring with agro-meteorological models and low resolution remote sensing methods and area estimates using high resolution data combined with ground surveys

Specific surveys: application of area-frame sampling techniques to provide rapid and specific information needed for the definition or reform of agricultural policies.

New Sensors and methods: following technological developments in new sensors, precision monitoring techniques and alternative data collection and processing techniques for large-scale agricultural applications

More specifically the project outline (1988-1998) consisted of 5 main activities (Meyer-Roux and Vossen, 1993; Meyer-Roux, 1995; se also: www.ais.sai.jrc.it).

Activity A: *Regional inventories assessment of the main crop acreage validating the results with ground truth data*. The data types for this type of classification is provided by high-resolution satellite imagery. The method tested at the start of this activity established close links between satellite data and observations on the ground. Only a part of these links that has proved to be cost-effective has been kept as operational. This relates mainly to stratification by visual photo interpretation of high resolution images. Medium resolution images, such as RESURS-01 (160m per pixel) has been used for stratification if landscape elements were large enough to be clearly identified at this resolution.

Activity B: *Crop state investigation and parametisation of yield indicators for entire Europe and fast dissemination of yield forecast*. The planted areas, state and type, are compared to the previous season. Data are provided mainly from SPOT and TM high resolution imagery. The general methodology of Activity B takes the following steps :

> -the acquisition of optical/infra-red satellite imagery for a sample of 40 by 40 km sites distributed over the European Union;
> -the rapid transfer of those images from the receiving station and processing facilities to the Activity B operational service;
> -the radiometric and geometric correction of the images;
> -the photo-interpretation of fixed small image segments localised in a site followed by the unsupervised classification and analysis of the corrected images to derive the areas occupied by agricultural crops or groups of crops at each site;
> -the statistical separation of the crops of interest at site level, followed by an aggregation of --the results obtained over the different sites to the level of the European Union.

The activities of the rapid area estimates are conducted throughout a full calendar year. Within a year the distinction is made between a preparatory phase (PREPS), corresponding to the winter period, and an operational phase (OPS), corresponding to the agricultural growing season.

Activity C: *Timely forecasting of agronomic production using existing agro-meteorological models and crop state and yield indicators obtained by remote sensing*. Collection of the data in an advanced agricultural information system. The data types are synoptical observations, agronomic data and satellite imagery with both high and low spatial resolution.

> *Component 1* : Vegetation Conditions and Yield Indicators. The principal objective of component 1 is to supply up-to-date information on the state of the vegetation over the whole of Europe. This entails monitoring the development

of the vegetation during the course of an agricultural season using low resolution satellite data captured by the NOAA - AVHRR satellite.
Component 2: The objective of component 2 (Yield Prediction Models) is the development, testing and implementation of a system for the timely area-wise crop state monitoring and quantitative yield forecasting at EU level of the following major crops: cereals, grain maize, rice, pulses, sunflower, soya bean, potato, sugar beet, rape seed, grape-vine and olive. This component comprises two separate sub-actions:
-the development and improvement of a semi-deterministic agro-meteorological model to predict annual crop yields;
-the development of a model to forecast vine (and olive) yields based on pollen count methods.
Component 3: The objective of component 3 (the Integrated System) is to integrate the various actions and also incorporate conventional surveys in order to create a complete information system including the new methods described above. It therefore succeeds all the preceding Activities.
Component 4: The purpose of component 4 (Area Frame Surveys) is (1) to provide image interpreters carrying out the "European Rapid Estimates" Activity with the ground data to build a knowledge base for each site for the year and validate the obtained results by satellite data in real time at the end of year (2) to obtain direct estimates of acreage and yields for the main agricultural crops at the European Union level, independently of remote-sensing techniques and (3) to provide information at the site level to be used by other prediction models.

Activity D: *The assessment of foreign agricultural production*.

Activity E: *Identification of improved methods for existing image data and investigation of new sensors for continuing or replacing ongoing tasks* (This activity has been concentrated during the second phase of the project).

4.3 Funding, users and products

Funding for the MARS programme comes primarily from the non-nuclear research component of the EU framework programme for research, scientific and technological development. The operational part is funded by DG VI and the member states.

The main users of the MARS products are EUROSTAT and DG VI.

Several of the MARS products are today operational and the results are published in the MARS Bulletin and distributed to relevant parties in the European Unions administration and institutions. Selected parts of the programme has been implemented on national scales in for example Belgium and Finland.
The operational phase of the MARS project is running in the summer each year from March till November. The MARS bulletin is divided into two parts:

- Rapid estimates of changes in planted areas

- Crop yield assessment and forecasting

4.4 Crop yield modelling

The crop yield model forecast is one of the important products of the MARS project. The yield forecast is made for all EU member countries based on meteorological ground information and statistics on acreage from national authorities, the parameters are: precipitation, temperature, climatic water balance, biomass, storage organ, crop development stage, soil moisture reserve. The forecast is made for the most common crop types. Similar forecasts are also made for European countries not members of EU and the northern African countries Algeria, Morocco and Tunisia. Socio-economic issues are not taken into account in the forecast even though that might be relevant for the latter countries. Status and analysis of the agronomical and agro-meteorological situation is performed using all available data types including satellite data. The analysis is done for the most relevant crop types in an area covering the countries also covered by the model forecast mentioned above. The MARS project has also to some extent communicated expertise to developing countries in Africa.

The EU Crop Growth Monitoring System (CGMS) operating on a European scale has been developed and set up during 1990-1994 by Dutch Winand Staring Centre for Agricultural Research under the MARS project and implemented operationally since 1994. In fact 3 model setups are included in this system: WOFOST, LINGRA and OLIWIN. The meteorological parameters used in the model are: precipitation, temperature, vapour pressure, 24 hour wind, sunshine hours/cloud cover. These parameters are interpolated in a regular 50 * 50 km grid covering entire Europe. The 3 different models are chosen according to region-specific characteristics such as soil type, crop parameters, planting and sprouting date (Vossen and Rijks, 1998). The model system is updated with 10 day steps and the results are published in monthly bulletins. Each month a data summary is produced by the model. The summaries and the 10-day outputs describe the meteorological condition indicators and the crop state indicators (e.g. development stage, leaf area index, soil moisture index and total biomass).

4.4.1 Model functionality

The models are driven by: Energy balance, water balance, potential evatranspitation, CO_2 assimilation, water requirement, water availability

The models are calibrated and set up for certain (local) conditions, this include:
-quantification of initial dry matter at emergence
-mean planting date for particular plant and location
-length of phenological stages: determined from temperature sums etc.

This and the following is based on Vossen and Rijks (1998). Estimation of solar radiation is described in one of 3 ways, depending on the data which are explicit available. The first, and preferred method, is a method described by Ångstøm using the sunshine duration at the nearby synop station. Often that information is not availabe and methods using the overall cloud cover estimate and temperature or only the temperature are used to calculate the important solar radiation parameters.

The evatranspiration is estimated using the ‘Penman formulae’. Extended versions of the ‘Penman formulae’ like the ‘Penman-Monteith formulae’ which could provide a more concise description of the evatranspiration are not used because the input information is not in general available. The Penman-Monteith formulae includes crop canopy resistance which is not given from the measured input data.

The soil database is based on a European scale 1:1 000 000 soil map. This map was corrected and harmonised during the MARS project. A soils database was developed with point of departure in this corrected map to include: soil typology, water capacity estimate for the top 3 horizons, maximum root depth and capillary rise capacity.

The measured parameters at the meteorological climate stations around Europe were interpolated by simple inverse weighting distance to represent gridpoints in the regular mesh. The criteria’s for this weighting are: proximity, altitude, distance to the coast, climatic barriers and other available stations in the area. The grid point spacing is 50*50 km. In practice the used meteorological stations providing data to the models are the SYNOP network with at least 4 available observations a day and daily delivery.

4.4.2 Operational models

The operational version of CGMS, was enhanced by introducing the capacity to directly forecast national yields employing the EUROSTAT's CRONOS database and by adding a number of user friendly facilities for the production of maps.

Basically, CGMS contains the following 3 modules:
(1) The processing of daily meteorological data, replacement of missing values; calculation of derived parameters such as solar radiation (from cloud cover or sunshine duration), vapour pressure and potential evapotranspiration; interpolation to a regular grid of 50 km x 50 km; production of output maps of the meteorological conditions during a given 10-day period, month or season, both as actual values and as departures from the climatological average conditions.

(2) The agro-meteorological crop growth simulation for each of the major annual crop types which, according to the crop knowledge bases, are likely to grow in a given 50 km x 50 km grid. Since various soil types and crop varieties co-exist in a grid, the output of a basic square is produced for each major soil type and available water profile capacity, so as to reach a representation of approx. 80% of the suitable soil coverage.

(3) The statistical module relating the model outputs through a regression analysis and possibly in combination with a technological time trend function drawn from historical yield data, to the series of regional and national yields available in EUROSTAT's REGIO and CRONOS databases. The regression analysis of past years is only used provided it gives satisfactory results in terms of significance of the multiple determination coefficient, the partial correlation coefficients, the stability of the regression coefficients and the error analysis; if not, only the time trend function or previous year's yield is used as predicted values.

The outputs of the system are: mapped outputs of indicators on the quality of the agricultural season: biomass and grain production, under actual rainfall conditions and as if all required moisture was available; estimated actual soil moisture reserve; differences as compared to the previous decade or month; state of development stage of the crop during a given decade.

Alarm warning: detection of abnormal weather conditions during a given decade or cumulated since the start of the season.

Tables with calculated yield forecasts: information on the quality of the regression equations such as the coefficient of multiple determination, the stability of the regression coefficients, the errors of the one year ahead predictions obtained from previous years, etc.

4.4.3 Operational models on a regional level

The adaptation of crop yield models as for example the CGMS, on national or regional levels has been done in Finland and Belgium. Special versions for four Mediterranean regions, namely Sicily, Sardinia, Languedoc-Roussillon and Andalucia, were also developed. The work to produce "tailor-made" versions for Finland, Belgium, and some of the Central European countries is described in papers (Buffet et al. 1999; Ikaheimo, 1999; Nieuwenhuis et al., 1998; Rosema et al., 1998; Tavares et al., 1998).

Adapting the European scale model to a regional or national scale is related to certain problems in the model structure and set-up: The input information must be relevant for the scale on which the model is operating (e.g. meteorological measurements must be representative for the grid scale of the model), the scale for all the inputs must be of the same order (e.g. soil information and meteorological data must be of same scale) and all the information must be provided in a efficient supply system and integrated with respect to the format used in the model. For the models, on regional and national scale, to have value for the relevant national authorities the spatial resolution of the output must be improved as a first measure. This involves the soils data base as well as the input of meteorological measurements and plant stage information to be re-interpolated in a representative grid. The original European model system: CGMS, is operating in a 50 by 50 km grid point spacing and the input and output information is adjusted to this scale. When adopted to the Belgian area the model grid point spacing was reduced to 10 by 10 km and for example the meteorological input on a daily basis came from up to 150 stations distributed over the country compared to the total of 700 stations used for the entire Europe. Also the output and distribution needs differed from the European scale model and a new distribution system was developed for this purpose.

The national statistics Institute in Belgium has an estimation system set up for monitoring agriculture. This consists of 50 groundbased agricultural correspondents reporting the state of the crops from all regions of Begium. There are however no harvest and crop yield prediction system in Belgium. A predictions system on a national level would be of interest for several parties e.g. agricultural sector, trading sector and the government (Buffet et al. 1999). The European scale CGMS has been adopted to Belgian condition and applied operationally Completion and a number of improvements and adjustments of the databases that specify the local agrometeorological conditions is necessary the European model is implemented on a national scale. The table shows the the difference between a national model and a European scale model:

	CGMS	Belgian-CGMS
Administrative zones	Normenclature of Statistical Territorial Units	14 zones per agricultural zone and 27 per circumscription
Grid	50*50 km	3 levels: 1*1 km, 5*5 km, 10*10 km
Soil data	1:1000 000 and 1:5000 000	1:500 000 and Aardwerk database of soil profiles
Suitability	based on soil types	additional use of land use data
Soil mapping unit	1 elementrary mapping unit consists of more than one simulation unit	1 elementary mapping unit corresponds to one simulation unit

Table 1 Differences between CGMS and Belgian-CGMS (Buffet et al. 1998).

Satellite data has not directly been implemented in the Belgian nor in the Finnish yield prediction model but the possibility is being evaluated in Belgium (Buffet et al., 1999). In Finland the crop yield prediction model has been implemented operationally in 3 test areas. The plan is to extend the model areas to cover all of the most important agricultural areas in Finland. The Finnish version of the model is not incorporating remote sensing data (Ikaheimo, 1999).

For distributing the model information the Belgians has chosen an internet approach because it can serve a wide user community with simple means of presentation not using specialised GIS systems installed with the user (Buffet et al. 1999). On this internet page the users can log on and acquire information on the project GIS server which is produced by the Belgian CGMS model.

4.4.4 Model evaluation

The results from the models are often available faster than the yield forecasts from EUROSTAT, which also receives information and predictions from national statistical institutions and presents a forecast. EUROSAT is using a regression analysis in combination with a time trend function for their yield forecasts. Investigating the predictions from EUROSTAT and CGMS shows that the time trend function analysis From EUROSAT is often more significant that the CGMS model outputs (Vossen and Rijks, 1998). However combining the model predictions with the predictions from EUROSTAT does overall improve monitoring and yield forecasting of crops, especially on a national scale. The ambitions with the CGMS forecasts were never the less initially higher: 'The relative modest contribution of the agrometeorological model out puts to the quality of the yield forecasts is somewhat disappointing.' (Vossen and Rijks, 1998).

The shortcomings of the model has been summarised by Vossen and Rijks (1998):

-at present the water balance module does not take into account possible capillary rise of soil moisture; the present water balance model is also a one-layer model.
-in the present version of the model, the planting date is fixed and has been put equal to the inter-annual mean value.
-the interpolation approach has without any doubt shortcomings, especially for what concerns the estimation of rainfall and radiation (from sunshine duration or visual cloud cover observations at station level).
-the fact that, at present, a maximum of two variables is taken into account (one trend variable and one output).
-errors in model parameters (e.g., the dry matter at emergence; sum of temperatures required to reach a phenological stage, repartition of biomass towards roots, leaves, stems, grain, etc.).

Instead input data to the model are retrieved from point measurements (e.g meteorological data) and ground observations (e.g. crop type, density, development stage, etc.). Using only surface observations has at least two disadvantages which could be excluded by the use of the proper remote sensing data: the 50 * 50 km grid cells are not covered representatively by the meteorological stations. The information from the ground observations do not arrive in due time from entire Europe.

Remote sensing information can provide estimates, such as NDVI and thereby Leaf Area Index (LAI), which is a direct input to crop growth models Nieuwenhuis et al. (1998) who also found an excellent agreement between parameters derived respectively from the crop growth model system CGMS set up for Sevilla, Spain and satellite remote sensing products. Especially the fine resolution Landsat-TM data had a good correlation with the estimates from the CGMS simulations. The correlation using NOAA-AVHRR satellite data and CGMS was not quite as good but could be used. Also Laguette et al. (1998) finds the use of remote sensing data in a regional study very useful: 'For operational purposes, a procedure including the 3M[7] model could permit appreciable improvements in the estimates of biomass and yield at a large regional scale, and replace or complete the forecasts obtained with the WOFOST[8] procedure.' This study is investigating areas in Italy, Spain, Greece, France, United Kingdom and Germany and is using archived data. Even though remote sensing data has not been implemented in the operational crop growth forecast models on a European scale several studies show that they can be implemented successfully at least on a regional level (Nieuwenhuis et al., 1998; Rosema et al., 1998; Tavares et al., 1998).

[7] *Modified Monteith Model: the Monteith parameters are expressed as a function of NOAA-AVHRR satellite data (Normalised Difference Vegetation Index and Surface Temperature) and transformed to a format which is comparable to model outputs.*
[8] *CGMS system + adapted WOFOST model, currently used within the European Commission to predict crop biomass.*

4.5 Satellite remote sensing data

4.5.1 Activity B

Satellite images are used operationally as a supplement to the CGMS forecast. Under Activity B, 60 sites 40*40 km in size, distributed over EU + Poland and Switzerland are analysed with Landsat TM and SPOT-XS satellites images. These 60 areas are monitored regularly and selected crop types are analysed with respect to changes in acreage. The analysed cereals include: wheat, barley durum wheat, rye, triticale, oats and maize. The oil seeds include: rape sunflower, soya and oil flax. The category other crops include: Green maize, dried pulses, peas, sugar beets, potatoes, rice and cotton. The analysis results are known as "Rapid Estimates" because they represent early estimates of changes in planted areas presented as crop state investigation and parametisation of yield indicators for entire Europe and fast dissemination of yield forecast. 60 sites of 1600 km^2 each are monitored by Landsat-TM and SPOT-XS.

During the PREPS phase (winter), where satellite images are acquired, the agricultural campaign of the following spring and summer periods is prepared. The bulk of the work carried out in this period consists of the validation of the per site and per segment classification results against ground survey data acquired independently from Activity B throughout the previous OPS phase (growing season). In addition, an updating of the masks containing non-agricultural surfaces takes place in order to adapt for possible changes in the general land-use at the site level. The OPS phase is characterised by an industrial approach to data delivery, processing and interpretation/analysis for which strict time limits need to be respected.

A maximum of 4 images per site are programmed for acquisition within a given year. This acquisition schedule is determined by four "windows of opportunity", based on local crop calendars, to maximise the chance of discriminating between crops at the site. During the acquisition campaign, the image companies inform the Activity B service when they acquire a cloud free image of a site during an open "window". Acceptance of this image by the Activity B service then closes the window for that site. Following acceptance, the image is rapidly shipped to the Activity B service, where it is calibrated and undergoes atmospheric and geometric corrections. The corrected image is then interpreted, classified and analysed to derive the agricultural crop area of the site.

The radiometric correction entails a conversion of raw digital counts to calibrated top-of-the- atmosphere reflectance values, followed by a correction for atmospheric effects to derive surface reflectance values. The objective is to provide image interpreters with a time-series of images for which the variations in pixel intensity, unrelated to changes in vegetation state, are reduced to a minimum. Interpreters can then pass the reflectance values through a single look-up table for display purposes, independent from the acquisition date of the image or the sensor used (SPOT 1, 2 or 3, TM), provided they have the same spectral resolution. Since 1993, these corrections are bundled in the operational software "Geometric & Radiometric Image Processing System" (GRIPS). Developed by GeoDesign and CISI (France), it performs the radiometric correction and geocoding of SPOT 1, 2 or 3 as well as Landsat Thematic Mapper scenes, quarter-scenes or mini-scenes in raw data (ESA/Earthnet) format. The output data are geo-coded image products, whole or partial SPOT scenes or Landsat Thematic Mapper scenes or partial scenes

The number of images to be processed impose an operational approach to the image analysis. This involves a dedicated system comprising of computer-aided image interpretation without access to up-to-date ground data, a knowledge-oriented data base, automatic single-date classification, multi-temporal cross-classification as well as the validation of the interpretation once a year, using ground data collected specifically for this purpose. With the present software system, which forms the backbone of the information system, it takes an image interpreter about 2 days to analyse a single image. The peak sustainable throughput of the current system is just over 2 images per interpreter per working week. Combined with the other constraints of data volume and flow, this results in a system configuration where, for the actual number of active sites, 6 interpreters can work simultaneously and independently.

Essentially, the objective of Activity B is to establish, on a fortnightly basis, a value expressing the area change of 17 crops of interest for the EU. The conjuncture task can therefore be considered as the pivot of Activity B, where "raw data" is converted into statistical information. The crops of interest are the following: cereals, further divided in 5 crops, i.e. soft wheat, durum wheat, barley, grain maize and other cereals; the group of dried pulses with field peas and other dried pulses; the oil seeds group with rape seed, sunflower and other oil seeds; a mixed group of 7 crops, i.e. rice, potatoes, sugar beet, green maize, temporary grasses, perennial green fodder and fallow land.

The Information Collation and analysis task is meant to overcome the three main obstacles in using images from sample sites for the estimation of areas under cultivation at European scale.

The precision and timeliness of the statistics produced by the collation and analysis task force are considered the touchstones of Activity B as a whole. Statistics given by other official or commercial sources are used as benchmarks against which the Activity B statistics are regularly compared. The principal reference is nevertheless provided by the EUROSTAT statistics, which are usually first published in autumn and continue to be revised until spring of the following year.

4.5.2 Activity C

The objective of the remote sensing component of activity C is to use satellite Meteorological data for monitoring vegetation conditions and providing indicators of the yields of the main crops' (Vossen, 1996). Doing that two indicative parameters which can be derived directly from the NOAA-AVHRR (and SPOT-VEGETATON) data by combination of channels, are extracted, namely a vegetation index and surface temperature. The same two parameters are directly related to the state and yield of the crops. This type of supporting information has proven to be very valuable to image interpretation when assigning crop labels to radiometric classes. In addition, agronomic and socio-economic information is collected from other sources such as specialised reviews, national or regional statistical bulletins and press revues, which provide essential background knowledge to the interpretation and the discussion of the observed crop area changes.

By use of the NOAA-AVHRR data it is possible to derive the normalised difference vegetation index as a function of time (NDVI). This is done operationally and updated every 10 days for entire Europe + Turkey and parts of Morocco, Algeria and Tunisia. The NDVI is directly related to the crop state where high NDVI values indicate high density of green leaves while low values indicate areas with sparse vegetation or stressed plants. The normalised difference vegetation index (NDVI) is found using the convex-hull method (Genovese, 1998).

The NOAA-AVHRR data are calibrated corrected and ingested into the pre-processing chain with a special purpose software system SPACE (Software for pre-processing AVHRR data for the Communities of Europe). The products from this software are the input for the production of images, maps or temporal profiles of geophysical parameters such as vegetation and surface temperature indices (see also: www.ais.sai.jrc.it). After the pre-processing with the SPACE software corrections for the atmosphere and cloud masks must be applied to the data for the measurements to be properly corrected and relate to surface properties. Different software modules were developed to apply cloudmasks and atmospheric correction.

4.6 10 year status of MARS

When the first 10 year period of the MARS project had been concluded, the future of the project was yet undecided. It was uncertain if the European Commission would prolong the project in order to continue the existing operations or actually close the project after the many years of establishment and operation. The MARS crop yield modelling results have been somewhat disappointing, and remote sensing data have only partly been implemented operationally (Vossen and Rijks, 1998). On the other hand the MARS forecasts and monitoring is a very useful supplement to existing information, the models has been implemented on regional and national scale with success not only in Europe but also in African countries where agricultural monitoring and forecasting before was limited or even non existing.

The MARS project was extended additional 3 years under restricted conditions and the project was changed on important points. For example area frame sampling (Activity B) using high resolution remote sensing data is now an integrated part of the system of operational products. This has been effected in order to promote the use of remote sensing data in the project output, which was found to be too sparse and nonintegrated during the evaluation. Activity B is extensively using high resolution SPOT and Landsat TM imagery and to some extent RADARSAT SAR data. Under activity C NOAA-AVHRR and SPOT-VEGETATION are used to generate indicators of surface conditions but still without direct integration with the CGMS model calculations.

On the MARS Conference 'Ten years of demand driven technical support' held in Brussels the 22nd and 23rd of April 1999 it was clearly stated that the MARS program has contributed significantly to the European pool of knowledge and experience within the field of remote sensing used for agricultural purposes and that MARS has initiated a notable amount of technology transfer within EU and to Eastern European and African countries. Furthermore MARS has influenced the structure of the CEO program and the 4th and 5th framework programme where increased emphasis was put on the application side and the user and customer involvement .

5. DMI and MARS

During the project period two approaches were followed to investigate if DMI should establish activities related to the MARS project. One approach is concerned with the EUMETNET JRC/SAI discussions and the other approach is related to the possible co-operation with Danish institutions, in particular Danish Institute of Agricultural Sciences (DIAS).

5.1 The EUMETNET approach

The discussion about a possible DMI participation in an operational continuation of MARS was initiated when the Commission suggested that the operational responsibility for MARS should be transferred from JRC/SAI to an European public institution, notably a Meteorological. In early 1998 JRC/SAI contacted EUMETNET concerning the operational continuation of MARS and during EUMETNET Council 6 February 1998 a proposal was discussed concerning the co-operation with the JRC concerning the continuation of the MARS project. In May 1998 the EUMETNET working group concludes that EUMETNET is not an organisation that should deal directly with and be responsible for operational activities for third parties. The activities involved in the proposal were of a kind that could only be dealt with by individual NMSs or by a consortium of NMSs. The working group therefore suggests that there should be no direct contact between JRC and EUMETNET regarding the required services. However, EUMETNET could play a facilitating role between JRC and individual member NMSs.

In June 1998 it appears that JRC/SAI might decide to look for a short term interim solution for the operational continuation of MARS and in parallel analyse the possible future scientific and technical evolution of such an activity. In particular, output from meteorological NWP models could be used instead of their present set of synoptic data. To investigate this further JRC organised a workshop concerning meteorological application in SAI projects in October 1998. EUMETNET, ECMWF and several NMSs participated, e.g. Meteo-France, UK Meteorological Office, SMHI and DMI. The purpose of the meeting was:

- to provide information to the participants on the ongoing and planned activities of the JRC/SAI in so far as they are related to meteorological data and information.
- to establish a framework for collaboration between JRC/SAI on the one hand and the national meteorological services in Europe and the European meteorological institutions (ECMWF, EUMETNET, EUMETSAT) on the other hand.

It was established that many of the JRC/SAI activities could benefit from information exchange between the JRC/SAI and NMSs, ECMWF, EUMETNET and EUMETSAT but it was not evident in which form JRC/SAI envisaged this information exchange. Furthermore, it was stated that JRC has developed a number of tools. Those on crop monitoring and yield forecasting are ready for transfer to DG-VI, and those relating to aspects of agrometeorology can be shared with other users. Among the potential users that had manifested themselves were a number of regions or provinces, that requested application of the developed methods. JRC wishes that the tools that have been developed and proven, should now be used and receive the necessary visibility. The software that had been developed was JRC property, and could thus be transferred freely.

The interest of the NMSs to collaborate with JRC/SAI was greater for the research and development aspects than for operational implementation, which should rather be a national effort, that should not be duplicated.

Following this workshop an ad-hoc working group was established having the objective to prepare proposals for co-operative research projects between JRC teams and teams of NMSs, ECMWF or EUMETSAT to be identified. The scope was to address the development of applications on the European scale with meteorological and climatological aspects, linked to crop monitoring, crop yield forecasting, monitoring and short term forecasting of natural hazards (forest fires, floods, drought, storm surges) and to propose mechanisms for monitoring the progress of co-operative projects which would be decided, facilitate the transfer of successful pilot projects to operational activity and evaluate their impact. A structured collaboration would benefit both NMSs and the JRC: (1) NMSs by using JRC as a preferential gateway to EU DGs requirements and (2) JRC by having access to NMSs expertise, data set and scientific staff. Furthermore it could offer clear economic benefits and political advantages for the effective functioning of a working group including NMSs and JRC (EUMETNET, 1999).

DMI participated in following meetings which were concerned with definition of a research strategy for JRC and the NMSs and identification of possible research proposals meant for the 5th Framework programme. As a valuable outcome of the ad-hoc working group meetings proposals to the 5th framework programme were prepared. DMI contributed in particular to the 'Flooding' and 'Rainfall Climatology' proposal. The 'Flooding' proposal focused on setting up an European Flood Forecasting System (EFFS) and it was submitted to the 5th framework programme by June 1999. The proposal has been accepted.

The ad-hoc working group report (EUMETNET, 1999) concludes that JRC/SAI should approach various DGs and EU institutions to identify requirements in term of meteorological information and possible founding for elaboration of Pan-European (agro-) meteorological geographic information. To define and monitor these co-operative development programmes, EUMETNET and JRC/SAI propose to establish a specific working group (continuation of the ad-hoc group currently in existence) following the work programme defined in 'Potential for co-operative development projects'.

5.2 The Danish perspective

The Danish perspective covers two ways of co-operation: (1) a joint Danish involvement in the continuation of MARS and (2) a Danish co-ordination of research projects which are related to MARS and which may or may not be facilitated by EUMETNET, primarily proposals to the 5th framework programme.

The potential for a joint DIAS/DAS and DMI participation in MARS has been investigated through inter-institutional discussions, which have taken place as part of this project. DIAS has, as an agricultural research centre an obvious potential for participating in the MARS project. The Danish Institute of Agricultural Systems Department of Agricultural Systems (DIAS/DAS) participated initially in MARS under activity B where they processed and interpreted high resolution satellite imagery in terms of land use classification. This activity stopped in 1995 due to lack of sufficient financial support from EU. DIAS/DAS has never contributed to components under activity C nor have they been approached by MARS within this context. DMI has expertise in operational numerical modelling and remote sensing applications and have direct access to relevant meteorological data. DMI and DIAS are already involved in projects of common interest, i.e. DMI is for example currently running the project: AMIS which is providing meteorological data operationally in a 10*10 km interpolated grid from synoptical stations in Denmark. These data are used both in a crop information and protection system which are running operationally at DMI and DIAS/DAS and is providing farmers with relevant agrometeorological information.

One driving force for a collaborative effort would be a request for MARS or MARS like products from Danish users. The Danish statistical office and the Ministry of Food and Agriculture and the agricultural community are potentially users of Danish MARS products. DMI and DIAS/DAS has been investigating the possibilities of involving these partners and users and have investigated if there indeed is a request for MARS products among Danish users.

The Danish Statistical office is collecting agricultural information through a network of agricultural advisers in Denmark. This information includes acreage, crop yield etc. and are relayed to relevant institutions among them the Ministry of food and agriculture and EUROSTAT. The report network of statistical raw data is secured by law imposing the relevant organisations to inform to The Danish Statistical Office. The system is both by the Ministry of Food and Agriculture and Danish Statistics characterised as very well functioning and reliable fulfilling the need for agricultural statistics. In other words there are no direct user driven demand to further develop the existing products.

The type of new information, an adoption of a MARS setup, would add to already existing agricultural statistical information in Denmark would be crop yield forecasts from hybrid GCMS models in local and regional applications. However there is at the moment no requested need for crop yield forecasts among the Danish users of agricultural information. The crop types and the climatic conditions in Denmark are furthermore not favourable for crop yield forecasting. It seems as if the need for forecast or monitoring products in Denmark is focused on problems like drought/irrigation and disease/chemical crop protection. These issues require very high resolution remote sensing data in order to monitor changes in the plant state patterns i. e. SPOT, Landsat TM and possibly RADARSAT SAR imagery which is not supported by MARS activity C remote sensing nor modelling activities which works on a different scale.

Another driving force for an increased collaborative effort may be an improved success rate for proposals submitted to research funds and that a broader scope of proposals may give both DMI and DIAS access to a wider range of research funds. This may be achieved by a co-ordination of research initiatives and by exploiting research areas with a strong user involvement of common interest. Especially projects under the 5th EU framework programme could pave the way for research and implementation of MARS or MARS-like products at the two institutions. Two types of 5th frame programme applications have been discussed:

1. Research and development projects where new agricultural and agri-meteorological products specifically tailored for Danish users are developed. The products which are interesting

for Danish users are especially related to the issues: Land use classification- acreage, parametrisation and monitoring of crop disease and drought. The data types which are suited for that type of detailed monitoring is foremost SAR but also high resolution optical/infrared sensors like SPOT and TM. The SAR data has the advantage which is particularly relevant in the Danish area that it is independent of cloud cover and daylight.

2. Setup and adaptation of a CGMS model for the Danish area to obtain a crop yield forecast product. Similar adaptations of the GCMS model has been done in both Finland and Belgium. The challenge adapting such models for local/regional conditions lies in the scaling and interpolation of input data.

DMI is at the moment not pursuing expertise in remote sensing with agricultural applications. Research in this area of remote sensing would therefore not be in continuation of existing activities or support the long term strategy and knowledge accumulation at DMI. Involvement in a EU 5th framework programme application concerning research in agricultural remote sensing is therefore not in the interest of DMI.

For setting up a GCMS model at DMI there must be a requested need for the new product which the model can provide in comparison to existing methods namely the crop yield forecast products. At the moment there is no such requested need for crop yield forecasts in Denmark. The modelling strategy at DMI is to develop already existing schemes to provide requested products instead of introducing new models and thereby complicating the selection of products. A EU 5th frame work application for introducing a Danish GCMS model is therefore not in question.

5.3 Invitation to tender

As the complete Invitation to tender is not yet available the following conclusions are only based on the 'prior information notice' shown in appendix 7.1. Consequently it is difficult to estimate the economical aspects of a possible involvement, e.g. necessary investments and resource allocations. The recommendations are therefore primarily based on an assessment of the potential benefits, e.g. to which extent an involvement could improve DMIs present products or allow DMI to develop new products which could broaden the DMIs customer base. It is important to notice that the contract period is two years with two possible one years extensions, and that a given tender may cover one or more lots . In the following the numbers refer to the 'lot numbers' in the prior information notice.

1. Real time provision and quality control of meteorological data. This task is clearly within DMIs line of work and therefore as such interesting due to potentially low investments in equipment and human resources. This task is today taken care of by a Dutch company named 'Meteo Consult' and it is evident that it may be difficult compete in terms of price and services as Meteo Consult already provide this information to JRC. However, the meteorological data set is used as input to some of the other tasks and involvement in one of them may have a positive impact. This task may be designated as an 'sales' task with no other positive impact on DMI than a potential income. If this income is doubtful or marginal no tender should be submitted.
2. Operating CGMS. It is impossible to tell from the prior information notice if the whole software suite (the CGMS) will be transferred to the contractor or if the model is still at

JRC and remotely executed by the contractor. If the model is going to be transferred to the contractor it is important to analyse to which extent the model is transferable in terms of software structure and hardware requirements. Likewise the amount of human resources necessary to run and maintain the model must to be estimated. It may be important to remember that according to DIAS CGMS-like models already exists in Denmark and it is consequently not necessary to adopt the CGMS to have access to an agro-meteorological model. Furthermore one key element could have been a strong inter operability between CGMS and HIRLAM but at this stage there are no links between the two models. Based on the available facts there seems to be no advantage for DMI in terms of potential new products or scientific gains of any sort connected to being operating the CGMS. Furthermore it seems as if no requirements for MARS or MARS-like products were expressed by potential Danish users. A MARS related product development and potential enlargement of DMIs user base consequently seems unrealistic. Consequently it is difficult to see why DMI should submit a tender.

3. Managing the processing chain for NOAA-AVHRR and SPOT-VEGETATION. Again it is impossible to tell from the prior information notice if the whole processing chain will be transferred to the contractor or if the processing chain will remain at JRC and remotely executed and managed by the contractor. Also the impact on infrastructure and hardware and the level of human resources required is impossible to estimate. DMI has already access to all the NOAA-AVHRR data which is needed for its applications and managing the processing chain will therefore not offer any new possibilities. Based on the available fact the processing chain itself (in principle the SPACE software) seems to be very effective and are at the moment being installed at several (mostly African) institutions. However, as it is difficult to imagine why DMI should adopt the SPACE software instead of the AAPP software package which is supported by EUMETSAT as its new NOAA-AVHRR processing chain, there are no technical / scientific benefits or reasons for being involved in managing the processing chain for JRC.
4. Provision of agro-meteorological products for additional areas not covered by lot 1. Participation in this lot will depend on the evaluation of lot 1 to 3. If there are no interest in submitting a tender covering lot 1, 2 and 3 no tender should be submitted for this one.

6. Recommendations

The successful realisation of the project objectives was to some extent dependent on the actual scope for the operational continuation of MARS. The fact that the prior information notice describing the invitation to tender was not available until October 1999 and that the complete invitation to tender was not ready at the deadline of this project, made if difficult to reach firm and detailed recommendations.

6.1 Operational continuation of MARS

Although the preliminary conclusions presented in section 5.3 were rather pessimistic it is recommendable to analyse in details the full invitation to tender when it is released. It cannot be ruled out that part of the invitation to tender may be economically interesting. If it is decided to tender it is recommended to concentrate on lot 1 and 3 as they are both well within the field of interest of DMI.. However, it is evident that more detailed information are required to analyse this in depth, e.g. concerning the processing of low resolution satellite data; will that require data to be sent to DMI, processed and then distributed to JRC. If this is the case the influence on and the investment in manpower, infrastructure, computers and software of cause needs to be analysed. However it is the impression of the authors that it is the intention to let the contractor only manage a processing system which is executed at JRC. The positive impact of such a set up on DMI is only marginal. Consequently, based on the available facts and the evaluation of the technical and scientific impact of an involvement in an operational continuation of MARS, it is the authors opinion that that DMI should not participation is not feasible or desirable.

6.2 Research opportunities

However, participation in research programmes related to certain aspects of MARS could be scientifically very interesting and should be pursued in the future, primarily as a collaborative effort together with DAIS/DAS. Likewise, DMI should try to profit from the positive impact of the JRC and EUMETNET involvement. Indeed, two research proposals were directly an outcome of the EUMETNET JRC/SAI contacts. The are two obvious research fields that could be investigated further in collaboration with DAIS/DAS, namely a) integration of remotely sensed information within crop growth models in an operational environment, and b) use products from NWP models as input to crop growth models.

7. Appendices

7.1 Invitation to tender

I-Ispra: operational activities for the MARS crop-yield forecasting system

(99/s 189-133233/EN)

Prior information notice

Directive 92/50/EEC

1. **Adjudicating body**: The European Commision, Diretorate-General Joint Research Centre, Space Applications Institute, Agriculture and Regional Information Systems (ARIS) Unit, for the attenuation of J. Meyer_Roux, TP 262, I-21020 Ispra.

2. **Nature of services to be provided**: The MARS project (monitoring of agriculture with remote sensing) of the ARIS units needs support for operational activities linked to its crop-yield forecasting system. The services are divided into separate lots:

-lot I: real-time daily provision of meteorological data covering the EU15, Central and Eastern European contries (western border of Russia included), Maghreb and Turkey, quality-checking of the data,
-lot II: operating the crop growth-monitoring system (CGMS): meteorological data interpolation and agro-meteorological indicator calculation, mapping of results,
-lot III: management of a processing chain for low-resolution satellite data: NOAA-AVHRR (including data purchasing) and spot-vegetation: production indicator and mapping outputs,
-lot IV: provision of agro-meteorological products for additional areas not covered by lot I. The operational areas will be defined in the ITT and could cover parts of Russia, The Middle East, Africa and South America. Data should be provided from meteorological models' output and low resolution satellite data. The tools to be used are similar to those described above.

Tenders may cover 1 or more lots. The Commision reserves the right not to award all lots. The work is sceduled in 3 contractual phases: 2000-2001, 2002 and 2003.

CPV No 73100000

3. **Date foreseen for publication**: Fourth quarter of 1999.
4. **Other information**: No further information will be available before the tender is published.
5. **Date of dispatch of the prior information notice**: 17. 9. 1999
6. **Date of receipt by the Office for Official Publications of the European Communities**: 17. 9. 1999.
7. The GPA of the World Trade Organization covers the services in question.

7.2 Support groups under the European Commission:

During phase 1 (1988-1993) of the MARS project the following institutions participated in the realisation of the work (after: Meyer-Roux and Vossen (1994), Vossen and Rijks (1995)):

The EU Support Group on Agrometeorology (SuGrAm).
The EU Support Group on Soils and Geographical Information Systems.

7.3 Contributing Institutions.

Institutions, organisations and companies which have contributed to the development and implementation of the MARS project methodology.

Agrometeorological Applications Associates S. A. R. L, France.
ADK, Greece.
AGPM, France.
AGRAR, Germany.
AQUATER SpA, Italy.
AURENSA, Italy.
BDPA, France.
Bureau of Land Data, Denmark.
CABO, Netherlands.
CEMAGREF, France.
Centre National de la Recherche Scientifique, Laboratorie Palynologie, France.
CISI, France.
CNES, France.
Cranfield Institute of Technology, Silsoe College, United Kingdom.
DGPA, Portugal.
DHV, Netherlands.
Ecole Superieure d'Agronomie ESAP-Purpan, France.
EFTAS, Germany.
EOS, United Kingdom.
ERA, Italy.
ESA, Europe.
EURIMAGE, Europe.
Expert Group 'Zonage Viticole' (established by DG VI, with the participation of a large number of institutions).
Faculte des Sciences Agronomique de Gembloux, Belgium.
FAO, United Nations.
GAF. Germany.
GEOSYS, France.
GISAT,Czech Republic.
Hand, Whittington Assoc., United Kingdom.
Hunting Technical Services, United Kingdom.
IBERSAT, Spain.

IGN-Espace, France.
INRA, France.
Instituto Cartografico de Catalunya,Spain.
ISPIF, Romania.
LERTS-Toulouse, France.
LOGICA, United Kingdom.
MAPA, Portugal.
METEO CONSULT, Netherlands.
METEO FRANCE, France.
NLR, Netherlands.
NRSC, United Kingdom.
Organotecnica, Greece.
Q-Ray-Agrimathica, Netherlands.
RSDE, Italy.
SATCART, Portugal.
SCEES, France.
SCOT Conseil, France.
Scottish Crop Research Institute, United Kingdom.
SGS-Qualitest, France.
Sodeteg, France.
SOTEMA, France.
SPOT Image, France.
STRABOS, Greece.
Sysame, France.
Tecnodata, Italy.
Telespazio, Italy.
The Meteorological Office, United Kingdom.
Trabajos Catastrales S.A., Spain.
University of Bologna, Italy
University of Copenhagen, Denmark.
University of East Anglia, Climatic Research Unit, United Kingdom.
University of Edinburgh, Institute of Ecology and Resource management, Scotland, UK.
University of Florence, Italy.
University of Gent, Belgium.
University of Leuven, Belgium.
University of Liege, Belgium.
University of Perugia, Italy.
University of Reading, United Kingdom.
University of Valladolid, Spain.
Vine grape, olive and fruit research stations and University Departments of 6 EU countries.
Winand Staring Centre, Netherlands.
World Meteorological Organisation (including the following meteorological institutes).

- Czech Hydrometeorological Institute , Czech Republic.
- Danmarks meteorologiske Institut, Denmark.
- Deutscher Wetterdienst, Zentralamt Offenbach, Germany.
- Helleic National Meteorological Centre, Greece.
- Hydrometeorological Institute of Slovenia, Slovenia.

- Institute of Meteorology and Water management, Poland.
- Instituto Nacional de Meteorologia e Geofisica, Portugal.
- Instituto Nacional de Meteorologia, Spain.
- Koninklijk Meteorologisch Instituut, Belgium.
- Koninklijk Nederlands Meteorologish Instituut, Netherlands.
- METEO-FRANCE, France.
- Servizio Meteorologico dell'Aeronautica, Italy.
- Slovensky Hydrometeorologicky USTAV, Slovakia.
- Swiss Meteorological Institute, Switzerland.
- The Meteorological Office, United Kingdom.
- The Meteorological Service, Ireland.
- Zentralanstalt fur Meteorologie und Geodynamik, Austria.

7.4 List of meetings.

List of meetings related to this project.

- Meeting with JRC, EUMETNET, ECMWF and NMS, 6-7 October,1998, JRC, Ispra, Italy (Erik Bødtker, Leif Laursen)
- Meeting at DIAS/DAS 22 January, 1999, DIAS, Foulum (Erik Bødtker. Leif Laursen and Henrik S. Andersen)
- Meeting with JRC, EUMETNET, ECMWF and NMS, 23 March,1999, ECMWF, Reading, UK (Erik Bødtker, Leif Laursen)
- MARS conference, Ten Years of demand driven support, 22-24 April 1999, Bruxelles, Belgium. (Henrik S. Andersen)
- Meeting at DMI with DIAS/DAS, Ministry of food and agriculture and Danish Statistical Office, 26 August, 1999, DMI, Copenhagen)

8. References

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I-2 (1999): Internet: http://www.dmi.dk/

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9. Glossary

AAPP, The EUMETSAT ATOVS (Advanced TIROS-N Operational Vertical Sounder) and AVHRR Processing Package
AVHRR, Advanced Very High Resolution Radiometer
CEO, Centre for Earth Observation
CGMS, Crop Growth Monitoring System
CRONOS, EUROSTATs database on agriculture
DAS, Department of Agricultural Systems at the Danish Institute of Agricultural Sciences
DG (VI), Directorate General (for Agriculture)
DIAS, Danish Institute of Agricultural Sciences
DMI, Danish Meteorological Institute
ECMWF, European Centre for Medium-Range Weather Forecast
ESA, European Space Agency
EUMETNET, The Network of European Meteorological Services
EUMETSAT, Europe's Meteorological Satellite Organisation
EUROSTAT, European statistical office
GIS, Geographical Information System
GRIPS, Geometrical and Radiometric Image Processing System
JRC, Joint Research Centre
LAI, Leaf Area Index
Landsat TM, Landsat Thematic Mapper
LINGRA, Grassland simulation model, based on LINTUL- Light Interception and Utilisation
MARS, Monitoring Agriculture with Remote Sensing
MARS-CAP, MARS: sector for Common Agricultural Policy
MARS-STAT, MARS sector for Agricultural statistics using satellites
METEOSAT, European meteorological satellite (EUMETSAT)
3M, Modified Monteith Model
NDVI, Normalised difference Vegetation Index
NMS, National Meteorological Services
NOAA, National Oceanographic and Atmospheric Administration
NOAA-AVHRR, Advanced Very High Resolution Radiometer, National Oceanographic and Atmospheric Administration
OLIWIN, model setup
OPS, Operational phase
PREPS, Pre-processing system
RESURS-01, Russian satellite (1994-1998) with spectral bands in visible and near infrared
SAR, Synthetic Aperture Radar
SAI, Space Applications Institute
SMHI, Swedish Meteorological and Hydrological Institute
Soils and GIS, Support Group on Soils database
SYNOP, network of meteorological stations
SPACE, Software for Pre-Processing AVHRR Data for the Communities of Europe
SPOT, Systeme Probatoire pour l'Observation de la Terre
SuGrAm, Support Group on Agrimeteorological modelling
WOFOST, World Food Studies, model setup