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# REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT

## on the implementation of the remote sensing applications and on the use of the financial resources made available to it under Council Regulation (EC) No 78/2008 (interim report)

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## 1. INTRODUCTION

Detailed information on the use of agricultural land and the conditions of arable crops is essential to the quality of yield and agricultural production forecasts. Such information is of particular use for market monitoring and the management of related market measures under the single Common Market Organisation. In this context, the European Union has made substantial efforts to develop and improve innovative technologies and models specifically related to remote-sensing applications. The experience accumulated has shown that remote-sensing provides independent information of high quality which cannot be obtained from traditional agricultural statistics and forecasting systems.

Council Regulation (EC) No 78/2008[1] provides the legal framework for these remote-sensing activities for the period 2008-2013.

The remote-sensing applications supported under this framework provide useful information to the European Commission but also to interested Member States, research institutes and other users, through a large dissemination of products. Since its inception, the system has been constantly improved. Beyond the primary objective to produce harvest yield and production forecasts, the system also provides useful insights into other fields relevant to the EU agriculture such as climate change issues.

The present report has been drawn pursuant to Article 4 of Regulation (EC) No 78/2008 which provides that the Commission shall submit an interim report no later than 31 July 2010 on the implementation of the remote-sensing measures and on the use of the financial resources made available to it under the Regulation.

## 2. THE MARS CROP YIELD FORECASTING SYSTEM

The system of production of crop harvest yield forecasts started in 1988 as a 10-year pilot project. The activity, which was then called Monitoring Agriculture with Remote Sensing (then abbreviated as MARS-STAT, now the acronym is AGRI4CAST), concentrated on the assessment of crop yields and production volumes of various crops within the EU, on the basis of meteorological analysis, agro-meteorological simulated crop growth indicators, low-resolution satellite data

[1] Council Regulation (EC) No 78/2008 of 21 January 2008 on the measures to be undertaken by the Commission in 2008-2013 making use of the remote-sensing applications developed within the framework of the common agricultural policy, *Official Journal of the European Union*, L 25 of 30 January 2008, p. 1.

and statistical analysis using the **Mars Crop Yield Forecasting System (MCYFS)**. From 1999 onwards this activity was implemented under the legal basis of Decision 1445/2000/EC[2] for the period 1999-2003 and its extension for the period 2004-2007 with Decision 2066/2003/EC[3]. Since 2008 and until 2013, this activity is implemented under Council Regulation (EC) No 78/2008. The system is operated in the Institute for the Protection and Security of the Citizen (IPSC) of the Joint Research Centre (JRC) at Ispra.

The MCYFS is a complex, integrated analysis tool addressing the objectives which are spelled out in the Regulation, specifically the monitoring of crop conditions, yields and agricultural production.

The system consists of several independent modules, which are integrated to monitor crop behaviour and produce crop yield forecasts. From a technical point of view, the MCYFS includes: 1) the maintenance of a meteorological database (see Article 1(2)(a) of the Regulation); 2) the application of agro-meteorological models (see Article 1(2)(d)); 3) the processing of low resolution satellite data (see Article 1(2)(a)); 4) statistical analyses and yield forecasts of the main crops at national level across the EU (see Article 1(2)(b)) as well as visualization tools.

The MCYFS is run operationally on an area covering the whole European Continent, the Maghreb countries and Turkey. The crops covered by the simulation models are soft wheat, durum wheat, winter and spring barley, grain maize, rapeseeds, sunflower, potato, sugar beet, field beans, pastures and rice.

More detailed information concerning the system and its outputs can be found in the accompanying Commission Staff Working Document.

*(1) Meteorological database*

Meteorological data are collected from meteorological stations throughout Europe. They are quality checked and further processed and analysed. As such they can be used to trigger risk warnings (e.g. detection of abnormal weather conditions during a given month). Furthermore weather forecast data from the European Centre for Medium-Range Weather Forecasts is analysed to prepare outlooks on weather conditions affecting agricultural land.

*(2) Agro-meteorological models used for crop growth simulation*

Agro-meteorological models are run to convert the meteorological data into estimations on crop biomass production. The tools used are the Crop Growth Monitoring System (the World Food Study model - WOFOST - adapted to the European scale), the model Lingra used for pastures and the Water Accounting Rice Model (WARM).

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2 Decision 1445/2000/EC of the European Parliament and of the Council of 22 May 2000 on the application of aerial-survey and remote-sensing techniques to the agricultural statistics for 1999 to 2003, Official Journal of the European Communities L 163 of 4 July 2000, p. 1.

3 Decision 2066/2003/EC of the European Parliament and of the Council of 10 November 2003 on the continued application of areal-survey and remote-sensing techniques to the agricultural statistics for 2004 to 2007 and amending Decision 1445/2000/EC, Official Journal of the European Union L 309 of 26 November 2003, p. 9.

Additional information, such as soil parameters, crop calendars, crop practices and crop parameters, is utilised to produce the simulations. At this level, many crop specific indicators/predictors (e.g. potential biomass) are produced and transferred to the statistical analysis to support the production of a quantitative yield forecast. These elements also contribute to the assessment of crop conditions (Article 1(1)(b) of the Regulation). Examples are maps indicating extreme temperature at a given crop stage, simulations of biomass and grain production, estimations of actual soil moisture reserve, the crop development stage in a given month, and the divergence from the long-term average at a given decade or period within the growing season for any agro-meteorological indicator.

*(3) Low resolution satellite data*

Remote-sensing applications feed into the system at all levels and contribute to improve the agricultural forecasting models as well as to establish regionally-based models. Information from meteorological satellites is used in addition to the data delivered by meteorological stations (e.g. radiation measured by satellites at the resolution level of 5 km). The remote-sensing information is processed to produce "measured" vegetation indicators which can be compared with the agro-meteorological indicators and used for the statistical analysis. Low to medium resolution satellite sensors are utilised: SPOT Vegetation/NOAA-AVHRR (about 1 km resolution) and MODIS (about 300-500 m resolution)[4].

*(4) Statistical analysis*

The indicators obtained from the meteorological database, the agro-meteorological database and the remote sensing database are compared to the yield time series and analysed with statistical methods (e.g. regression or scenario analysis). The final results are quantitative yield forecasts which, together with the analysis of the above-mentioned outputs, are published in the MARS bulletins. Data available in the system cover a long period of time, with series starting from 1975.

*(5) Visualization tools and dissemination of outputs*

The databases (meteorological information, agro-meteorological information, remote-sensing information) can be explored by users via information tools. The activity AGRI4CAST maintains a web portal where remote-sensing data can be screened and downloaded and a portal where the meteorological and agro-meteorological information can be viewed and downloaded in the form of electronic maps. It is also possible to download the analysis on crop conditions and yield estimates.

All elements listed above are utilised for the preparation of bulletins and specific studies on climatic conditions (see Article 1(2)(c)). They provide the analyses of the crop situation in different regions of the EU, maps of weather and crop indicators and yield expectations. The MARS Bulletin is published almost monthly during the main growing season on paper and on the internet.

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[4] The abbreviation SPOT stands for "Satellite pour l'Observation de la Terre", NOAA stands for National Oceanic and Atmospheric Administration and AVHRR for Advanced very high Resolution Radiometer, MODIS stands for Moderate Resolution Imaging Spectroradiometer.

## 3. IMPLEMENTATION

### 3.1. Overall implementation

For the continuation of the operational services from 2008 until 2013 according to Council Regulation (EC) No 78/2008, a new project, called MARSOP3, has been launched. It focuses on the provision of operational near-real time products to the JRC for the monitoring of agricultural production and yield in Europe. In August 2007 a call for tender (Operational activities for MARS actions (MARSOP3) 2008-2013, Contract Notice N° 2007/S 154-191094) was published in the supplement of the *Official Journal of the European Union*.

After evaluation of the offer for Lot I (meteorological data) and Lot II (acquisition and processing of satellite data) and favourable opinion of the Public Procurement Advisory Group, a contract was signed with a consortium led by Alterra BV.

On the basis of the operational products delivered within this contract, the JRC carries out the analysis of crop conditions and prepares the yield and production estimates. These are made available to the European Commission, Member States and EU citizens.

### 3.2. Implementation with regard to Article 1 of Council Regulation (EC) No 78/2008

Article 1 of Council Regulation (EC) No 78/2008 spells out the objectives with regard to the implementation of remote-sensing measures (Article 1(1)) and provides details on the measures to be undertaken (Article 1(2)). For ease of reference, the following description of the implementation of the measures follows the structure of Article 1.

#### *3.2.1. Aims of the implemented measures (Article 1(1))*

*Article 1(1)(a): management of agricultural markets*

The activity delivers independent, timely, scientific and traceable crop yield forecasts for all Member States and EU neighbouring countries for a selection of arable crops. This information is utilised by the Commission services for the following main purposes: 1) update of crop supply balance sheets; 2) assessment of climatic conditions and potential impacts of particular weather events in Member States or regions (e.g. impact of a late frost event); 3) monitoring of crop conditions in third countries. AGRI4CAST yield forecasts are also provided to the Early Estimate System of Eurostat.

Independence and reliability of the outputs prepared by AGRI4CAST are viewed as important assets by Commission services. The statistical analysis performed with the crop growth indicators is transparent, traceable and stored for all the crop simulation and years. A set of statistical indicators (e.g. root mean square error for different confidence intervals, standard deviation) is provided for each of the models. At the end of the forecasting campaign an error analysis is performed which compares the crop yield forecasts with the actual observed yields to quantify the yield forecast error and to evaluate the forecasting performance. For the sake of illustration, the overall error, measured as mean absolute forecast percentage error for the EU-27 in

2007 and 2008 across all months has been 1.6% for all cereals together. The target is an error below 3%.

*Article 1(1)(b): monitoring of crop conditions and estimates*

Besides yield forecasts, crop conditions are monitored closely throughout the growing season. Meteorological and remote-sensing information is analysed and linked to relevant crop information based on the results of biophysical modelling (e.g. impact of a hot wave or a cold shock at certain crop development stages). Furthermore, outputs of the crop growth model are directly used to assess the crop conditions (e.g. simulated leaf area index or simulated biomass). This monitoring covers the EU and applies to all crops listed in section 2.

*Article 1(1)(c): promotion of access to the estimates*

An open access to the various outputs is guaranteed by the websites maintained by the JRC and by the MARSOP3 consortium. The MARSOP website offers a wide range of information (results from the applied remote-sensing measures, crop growth model outputs, links to the bulletins). Satellite data and images are organised into an image server where the data can be viewed and downloaded. It is also possible to request and download meteorological data from the MARSOP website.

*Article 1(1)(d): ensuring the technological follow-up of the agro-meteorological system*

The JRC performs a constant technical follow up which ensures the continuity of the system and guarantees the scientific robustness of the methodologies applied such as the interpolation of the meteorological data onto a raster, the derivation of remote-sensing measures to describe the growing behaviour of crops or the statistical analysis performed to obtain the crop yield estimates.

*3.2.2. Measures to be implemented (Article 1(2))*

*Article 1(2)(a): collection and purchase of meteorological and satellite data*

The collection and purchase of meteorological data comprises 3 655 stations delivering information on weather parameters that are fed into the MCYFS on a daily basis. This service is maintained on a permanent basis. Freely available remote sensing data from low and medium resolution satellites (1 km to 300 m pixel resolution) devoted to vegetation monitoring are also acquired, stored, further processed and analysed.

*Article 1(2)(b): spatial data infrastructure and website*

Spatial data infrastructure comprises the technology, standards, human resources and related activities necessary to acquire, process, distribute, use, maintain and store spatial data. This infrastructure has been put in place with the MCYFS and the teams involved at the JRC and under the MARSOP3 contract. It covers spatial data sets for the whole of Europe in different scales. The data is processed to account for the needs of crop condition monitoring and forecasting of crop production. The outputs and information resulting from the different sources (e.g. remote-sensing) are made available via different websites and web portals.

The infrastructure complies with the framework set by the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive[5]: the spatial data is geo-referenced according to the INSPIRE projection, the metadata description follows the INSPIRE principles and will be further harmonized.

*Article 1(2)(c): specific studies on climatic conditions*

The system allows the preparation of specific studies on climatic conditions thanks to the large array of information available covering all relevant aspects. The following specific studies were carried out since Council Regulation (EC) No 78/2008 entered into force:

- Analysis of the impact of spring-summer drought and abundant rain in August 2008 on winter cereals production in Latvia;
- Analysis of the impact of extreme weather conditions during several days of July and August 2008 in Slovenia on agriculture;
- Water availability for rice growing in Spain in 2008 (analysis of cumulated rain fall);
- Analysis of the impact of 2009 winter frost events on winter cereals in Europe.

*Article 1(2)(d): updating of agro-meteorological and economic models*

Besides the operational running of the system, models and related databases are updated continuously. The database contains currently 2.5 terra bytes of information. Since the Council Regulation entered into force major improvements have taken place: the meteorological station network has been densified to ensure a better monitoring system; the resolution of the former 50 km x 50 km grid for the spatial analysis has been increased to 25 km x 25 km; new crop calibrations have been performed; and a new database and software version have been released.

## 4. DELIVERABLES AND OUTPUTS

The European Commission, Member States and other interested stakeholders are provided with different deliverables which can be grouped into reports and bulletins on the one hand and information services and data on the other hand. All products are made available electronically (Article 2 of the Regulation) and partially on paper format.

*Reports and Bulletins*

The crop monitoring bulletin for Europe offers, in near real time and operational context, information and analyses on crop growth monitoring and yield forecasting. Countries covered are those of the EU and neighbouring regions (Maghreb, Black Sea area). The crops covered are soft wheat, durum wheat, winter barley, spring

[5] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), Official Journal of the European Union L 108 of 25 April 2007, p. 1.

barley, grain maize, rapeseeds, sunflower, sugar beet and potato. A full analysis is published on the internet in general six times per year and supplemented by updated yield estimates two to three times per year. Dedicated bulletins for the EU are prepared for pastures and rice. Updates and reviews of agro-meteorological conditions are provided between the full analysis bulletins (10-12 times per year).

All these publications are made available via the internet but are also available upon request in paper format.

*Information services and data*

A large variety of information about the current agricultural production season in Europe and other important agricultural areas in the world is offered on the MARSOP web viewer and pages. Available products include graphs and maps of weather indicators based on observations and numerical weather models, graphs and maps of crop indicators based on agro-meteorological models and graphs and maps of vegetation indices and cumulated dry matter based on remote sensing images.

## 5. BUDGET RESOURCE USE

**Table 1. Use of financial resources under Council Regulation (EC) No 78/2008 in 2008 and 2009 (payment credits, in €)**

| | 2008 | | 2009 | |
|---|---|---|---|---|
| | Amount | Short description | Amount | Short description |
| LOT 1 / phase 1 | | | **1 016 084** | Interim and final payment |
| LOT 1 / phase 2 | | | **283 185** | Interim payment |
| Additional meteorological stations for LOT 1 | | | **67 800** | Near real time stations (more than 250) |
| LOT 2 / phase 1 | | | **387 720** | Interim and final payment |
| Lot 2 / phase 2 | | | **137 989** | Interim payment |
| MARS Database and information technology (IT) support | **97 298** | MARS DB and information systems maintenance and development | **477 562** | MARS DB and information systems maintenance and development |
| TOTAL | **97 298** | | **2 370 340** | |

**Lot 1** covers the procurement of meteorological and weather forecast data (including the densifying of network of meteorological stations). It covers the operational run and maintenance of the crop growth models operated within the MCYFS. Results in the form of database updates and maps are delivered to the database at the JRC daily or every ten days. Appropriate tools for exploitation of the results are maintained and developed. Maintenance and improvement of MARSOP website is also part of this lot together with overall coordination and management.

**Lot 2** covers the processing of remote-sensing data. The work performed covers all data enhancement steps between the acquisition of the raw imagery and the delivery of 10-daily composites (data ingestion, calibration, etc.).

**Mars database and IT support**: the MCYFS calls for the provision of IT services to ensure a timely production of bulletins. Work performed covers the management and maintenance of the database with all the remote sensing data, the meteorological data and the agro-meteorological indicators. Development and maintenance of analysis tools and websites are part of this component.