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REPORT FROM THE COMMISSION

on remote sensing applied to agricultural statistics during the period 1994-1998

Contents

Introduction

On 26 September 1988, the Council adopted Decision 88/503/EEC[1] adopting a pilot project on remote sensing applied to agricultural statistics (better known as the MARS project). This pilot project was intended to develop and test analysis techniques and methods to improve the information on agriculture in the European Union by incorporating more space data in the Community statistical information system. The development project was planned to last ten years, but the above decision covered only the first five years (1989-1993).

At the end of that five-year period, and in accordance with that Council Decision, a report on the first phase of the pilot project (1989-1993)[2] was drawn up and submitted to the Council, together with a proposal for continuing the applications which had become operational. On that basis, on 14 November 1994 the Council adopted Decision n° 94/753/EC on the continued application of remote sensing to agricultural statistics during the period 1994 to 1998[3].

The purpose of the applications covered by that decision was more particularly:

- to facilitate the use of remote sensing by interested Member States with a view to improving their national agricultural statistics systems (*Activity A - Regional inventories*);

- to provide estimates, before harvest, of acreages and potential production of the main crops at European and, if possible, national level within the limits of the financial resources available (*Activity B - European rapid estimates*).

Article 5 of Council Decision 94/753/EC stipulates that the Commission shall submit to the European Parliament and to the Council, by 31 July 1998, a report on the implementation of the measures and on the use of the financial resources put at its disposal for the purpose, "including, where necessary, proposals on the continued application of remote sensing to agricultural statistics". Part I of this report is devoted to those activities.

The Council also noted the Commission's intention to continue, during implementation of the *4th framework programme for research and development,* a number of measures forming part of the MARS project but requiring further research before they could be applied at European level. This concerns the following activities:

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[1] O.J. n° L 273 of 05.10.1988.

[2] Document COM(94) 332 final of 19.09.1994.

[3] O.J. n° L 299 of 22.11.1994, page 27.

- establishing an advanced agricultural information system at Community level by combining information obtained by various actions developed and tried out during the programme (*Activity C - Integrated System*);

- devising a method similar to that developed for the European Union to allow forecasts and early estimates of harvests in certain regions bordering the European Union, particularly East European countries and possibly the Maghreb countries, in liaison with the programmes for co-operation with these countries (*Activity D - Monitoring and prediction of harvests outside the Community*);

- continued research on the potential use of new sensors, such as radar, for statistical applications, to complement the high-resolution satellites and meteorological satellites currently used in the MARS project (*Activity E - Application of new methods or sensors*).

Part II of this report contains a brief description of these activities, carried out by the Ispra Joint Research Centre (JRC) in association with the Directorate General for Agriculture (DG VI) and the Statistical Office of the European Communities (Eurostat).

PART I - Operational activities

1. ACTIVITY A: REGIONAL INVENTORIES

1.1 Objective and methods

The purpose of this activity is to meet the need for accurate, objective annual information on acreages and yields at regional level for the main crops of interest. The methodology combines "high resolution" satellite data (covering the whole area of interest) and data obtained by "area sampling" surveys on the ground. Development and evaluation related mainly to the regression estimator method. The action was organised in two separate parts:

- objective ground observation with a sampling plan established or refined by remote sensing;
- the automatic classification of spatial data, improving the estimates of the ground surveys by a regression method.

Remote sensing also supplies the survey officer with documents enabling him to identify the exact location of plots on the ground.

1.2 Progress of the work

During the pilot phase of the MARS project, this action comprised three separate phases:

- 1988-1989: during this phase a strictly identical methodology was applied to 5 regions;
- 1990-1991: during this period, local adjustments were made and the active participation of the regions or national authorities was required;
- 1992-1993: during this phase the project was used to support national or regional initiatives.

At the end of phase 1 of the pilot project on remote sensing applied to agricultural statistics, responsibility for implementing this activity had been largely transferred to the Member States. However, in accordance with Council Decision 94/753/CE, technical assistance and finance could be provided under the Community budget, particularly as regards aid for technical statistics, the execution of pilot studies aimed at encouraging the use of area surveys to improve national agricultural statistics, and improvements to software.

During phase 2 the Spanish Ministry of Agriculture, Fisheries and Food (MAPA) and the Portuguese statistical services received assistance from the Commission in financing two projects in this sphere of activity. In particular, MAPA received a subsidy to develop a land-based panel for the early estimation of acreages and production of the main crops. The Portuguese Ministry of Agriculture received

Community finance to carry out a project on area survey methodology applied to the production of statistics on land use. In both cases, the Community contributed around 40% of the total cost of the project.

In connection with this activity, the JRC provided technical assistance for several European Union Member States and for countries taking part in the PHARE programme. In particular, Slovenia, Poland and the Czech Republic received technical assistance with regard to statistical methodology and sampling plans (cf. project Activity D). The JRC also provided technical support for some Mediterranean countries for the purpose of establishing regional inventories (notably Tunisia and Turkey) and arranged scientific exchanges with Morocco on this subject.

1.3 Financial aspects

Table 1 shows the EU's contribution to the two projects mentioned above.

Table 1 - EU contribution to "Activity A" (ECU)

	1996	1997	1998	Total
Ministry of Agriculture (Spain)	60,911	65,880	--	126,791
Ministry of Agriculture (Portugal)	60,150	--	--	60,150
Total	**121,061**	**65,880**	--	**186,941**

1.4 Conclusions and policy

In phase 2 of the project the "Regional inventories" activity was confined to financial and technical assistance for national statistical services requesting it, within the limit of the available resources.

The regional inventories are still a rapid, objective and often more efficient system, in terms of accuracy, when specific handicaps make farm surveys more difficult or less reliable. The scientific methodology developed could be used in the harmonisation of land use estimates for the whole of the European Union.

The area survey system is particularly appropriate for the PHARE countries, since it is difficult to maintain an up-to-date list of farmers, owing to the current farming reforms. This approach may however also prove useful for the whole of the European Union in meeting a growing need for information on land use, the impact of agricultural activity on the environment, the territorial dimension of agricultural policy and rural development measures, etc.

Given the high cost of the images, exhaustive annual coverage in high-resolution images and use of the regression estimator method are not a viable way of producing statistics at EU level and are therefore not recommended. That could change in the future, either with the arrival of new sensors and a reduction in the price of the images, or if statistics are produced in combination with cartographic products: hence the desirability of maintaining a technological watch on methodological aspects and the introduction of new sensors, including radar. We should also make better use at European level of the potential offered by area surveys to obtain

information on land use and on other statistical variables with a territorial dimension, for which traditional methods are less efficient.

2. ACTIVITY B: EUROPEAN RAPID ESTIMATES

2.1 Objective and methods

The purpose of Activity B is to provide an early, objective estimate of changes in the acreages of the main annual crops at European level by interpreting high-resolution satellite images obtained on a sample of 60 sites (40x40 km in size) distributed over the whole of the European Union. The method is based partly on estimating for each site the surface changes against the previous year and partly on extrapolating these changes at European level on the basis of the previous year's official statistics on acreages (source: Eurostat).

The method does not use any ground data for the current year but incorporates the previous year's ground observations, also permitting a retrospective check on the method's validity.

This activity has also supplied qualitative information during the agricultural year.

2.2 Progress of the work

In phase 1 of the MARS project, this activity was set up in three stages:

- 1987-1988: finalisation of detailed methodology;
- 1989-1991: establishment of the system and entry into production;
- 1992-1993: full-scale test of the activity (53 sites).

During phase 2 this activity became operational. The main stages were as follows:

- 1994: Transitional year pending the Council decision; no significant changes in methodology or organisation of the work.
- 1995: Call for tenders for the purpose of awarding the contract for photo interpretation and acreage estimation.
- 1995: First effective year of implementation of the Council decision. Establishment of the GRIPS and ORCA software by the JRC, for image correction, processing and classification respectively. Establishment of seven new sites to extend the activity to the three new Member States.
- 1996: Extension of the activity to 60 sites, with 7 covering the three new Member States (Austria, Finland and Sweden).
- 1996-1997: Establishment of the CAMEL software for the current situation task.
- 1997: Adaptation of the GRIPS software to IRS satellite images.
- 1998: Final year of implementation of the Council decision. Early use of windows for obtaining images to enhance the efficiency of the estimates in terms of stability and earliness.

2.3 Working procedures and the main developments

During phase 2 of the MARS project, working procedures for Activity B were essentially no different from those in phase 1. Nevertheless, although this activity was considered operational, several significant changes were made to both the system and the tools:

- Replacement of the software used up to 1995 by software developed under the supervision of the JRC, namely:

  - GRIPS, for the correction of satellite images;
  - ORCA, for the classification and photo-interpretation of the images;
  - CAMEL for analysis of the results and the data processing necessary to prepare the final estimates on the basis of the classified images.

  GRIPS and ORCA were used throughout phase 2. The CAMEL software was used from 1997 onwards. By using these software packages it was possible to rationalise tasks and gain control over all phases of the execution of the activity, thus ensuring quality control over the whole production chain. The GRIPS software was adapted between 1997 and 1998 to the new IRS satellite images (up to then, the only satellites used were SPOT and LANDSAT).

- Introduction of 7 new sites for the three new Member States, namely three sites in Sweden, two in Finland and two in Austria. One effect of this was better representation of spring crops.

- Establishment of a "radiometric knowledge base" to help the photo interpreters, taking account of the spectral signatures and climatic conditions observed in the past. This knowledge base is updated and extended each year, thus improving the system's quality.

The main results of Activity B were included in the MARS bulletin (see Activity C).

Between 1994 and 1998, the salient points were as follows:

- 1994

The activity continued in this transitional year between the research and operational stages. It followed the same procedures as in 1993. Altogether, 155 images were obtained on 53 sites.

- 1995

Altogether, 153 images were obtained, covering 53 sites. The results of the estimates were published in 7 MARS bulletins during the season. During this year the activity proceeded satisfactorily despite some specific problems encountered in validating the estimates:

- very large changes in the acreages of certain crops of interest, such as sunflower, partly owing to the effects of the CAP,

- over-estimation of the change in the acreages of certain crops such as colza, owing to the fact that this crop is poorly represented in the sample,

- the severe drought in Spain and Portugal, which made it very difficult to interpret the photographs and led to dubious estimates for a large proportion of summer crops.

In the case of sunflower and colza, the error increased the smaller the number of sites containing colza and sunflower, so that estimates are greatly influenced by relocation of these crops in Europe, as happened following the CAP reform.

- 1996

The number of sites processed was 59 out of 60 (there being no images for the Koping site), and the whole of the European Union was covered for the first time. Altogether, 171 images were obtained. The results were published in 7 MARS bulletins during the agricultural year.

- 1997

Altogether, 183 images were obtained covering all 60 sites. The main results were included in six MARS bulletins and three intermediate reports.

- 1998

Although the final results were not available by the time this report was written, it is worth mentioning that a number of changes were made to meet the need for improvements to results and management:

- acquisition dates were rationalised to improve discrimination between winter and spring crops, to achieve earlier stability in cereal estimates and to identify winter colza more accurately. This was made possible by the database of sowing dates produced from ground survey data associated with Activity B.

- adaptation of the GRIPS software to process the images from the Indian IRS-1C satellite, which will increase the likelihood of obtaining images on the sites on the set dates.

2.4 The role of the ground surveys

Implementation of Activity B during the second phase of the MARS project benefited from the results of the ground surveys conducted on the same sites with point sampling in a number of segments (on average, 16 segments 1400x1400 metres per site). The purpose of these surveys (known as «Action 6» during phase 1) was as follows:

a) to supply photo interpreters with ground information to establish the reference system for each site for year *n-1* and to validate the results obtained via satellite data at the end of year *n;*

b) to obtain direct estimates of acreages and yield forecasts for the main crops at European level, independently of remote sensing techniques;

c) to supply acreage and yield data for the main annual crops for each site, to be used as a statistical model for extrapolating the results;

d) to supply additional information on certain aspects which come into play in the agro-meteorological model (sowing, flowering and harvest dates, crop rotation, plans for the next year's sowings, etc.).

All the results of these surveys were stored in a database at the JRC and had a positive impact on other aspects. For example, the ground surveys were used to produce a database on spectral signatures and provide real data on sowing dates, etc.

2.5 Use of financial resources

Table 2 below gives a summary of expenditure on the operational implementation of Activity B from 1994 to 1998. It reveals that the overall cost of this activity for the EU budget during the period was ECU 11.8 million, or an average of ECU 2.4 million per annum, though it was closer to ECU 2.1 million in 1997 and 1998. This decline, which is all the more marked in comparison with the start of the period if we take account of the increased number of sites, is due mainly to cost savings on image processing for 1997 and 1998 following a call for tenders put out in 1995 for the award of this contract. The increase in 1996 is due to investment in information technology in that year by the contractor selected.

Table 2 - Total expenditure on "Activity B"[4]

	1994	1995	1996	1997	1998	Total
Processing	1,323,470	1,125,000	1,357,807	830,767	837,614	5,474,658
Images	632,007	633,719	666,400	655,455	660,000	3,247,581
Software maintenance			102,952	163,658	161,360	427,970
Ground surveys	554,853	489,919	581,966	503,593	481,288	2,611,619
Total	**2,510,330**	**2,248,638**	**2,709,125**	**2,153,473**	**2,140,262**	**11,761,828**

Broadly speaking, the operating costs can be divided into four types:

- purchase of images,
- expenditure on image processing and production of estimates,
- software maintenance,
- ground surveys.

[4] The number of images for 1998 is estimated.

Here is a brief description of each type of expenditure.

2.5.1 Images

On average, 3 images per site are processed in the course of each season; in practice, all the images are obtained between the beginning of April and the end of September. If an image is to be usable, there must be very few clouds. In some parts of Europe, cloudy weather may make it impossible to obtain any images during highly interesting periods in crop development.

Table 3 - Statement of images used by Activity B

Year	satellite			TOTAL	
	SPOT	LANDSAT	IRS	Images	Costs
1994	137	18		155	632007
1995	149	16		165	633719
1996	159	12		171	666400
1997	126	57		183	655455
1998*	120	40	20	180	660000
total	**691**	**143**	**20**	**854**	**3247581**

(*) Forecast

During 1994 to 1997 a total of 674 images were obtained and processed. During those years, two image suppliers were competing to supply the most suitable images at any time: Spot Image, which has exclusive rights to the images from the European satellite, SPOT, and Eurimage, which has exclusive rights to the images from the American LANDSAT satellite. To some extent, the SPOT and LANDSAT images are interchangeable. However, in practice the only way of ensuring that an image is obtained when and where necessary is to obtain the first available image for the chosen sites in the periods selected. The possibility of programming the SPOT satellite considerably increases the likelihood of obtaining good images from that satellite for Activity B, which explains the large number of images obtained from SPOT as opposed to LANDSAT. Very recently (April 1998), GAF/Euromap - the exclusive supplier of images obtained by the Indian satellite, IRS-1C - also re-entered this market. About 180 images are to be bought in 1998 from the three suppliers, as indicated in Table 3.

2.5.2 Image processing and estimate production

The term "processing" covers all the practical operations which take place following acquisition of the image and are necessary to prepare the estimates which the Commission expects. For a better understanding of the nature and level of expenditure on this, the sections below will give a brief description of the activities involved in "processing" the images.

2.5.2.1 Project execution and management

Management activities concern the organisation of the project as a whole, mobilising the necessary equipment and human resources and planning the timetable. During the execution phases, the management is responsible for the

operation of the production process, co-ordination between successive years and resolving problems and contingencies.

2.5.2.2 Project launch

This action takes place during the preparatory phase and concerns the launch of the entire production chain, i.e. the installation of the data processing equipment and commissioning of the software and the communications network. When a long-term production chain is installed (several consecutive years), expenditure on this type of activity is charged to the first year only.

2.5.2.3 Preparations for the season

This work can be divided into two main parts: validation and site preparation. Validation consists in evaluating the quality of the photo-interpretation results by comparing them with ground surveys conducted on each of the sites in the previous season. Site preparation consists in collating all the information on previous agricultural years; this information is preserved to improve the knowledge base on the sites (crop rotation tables, site profile, image reference system, definition of the regions, etc.)

2.5.2.4 Acquisition and preliminary processing of satellite data

When the image is received, it is checked to ensure that it is acceptable (date taken, image quality, rate of cloud cover, etc.). Next, the image undergoes a series of processes aimed at eliminating any influence due to atmospheric conditions, the satellite photography parameters, the type of satellite and the local topography. These processes may be roughly classified into two types: radiometric and geometric; they are carried out using the GRIPS software owned by the Commission.

2.5.2.5 Interpretation of satellite data

This fundamental phase comprises several operations which we can divide into six consecutive stages: a) data integration, if the preceding correction phase has been validated; b) automatic classification, by allocating the image to one of about thirty homogeneous classes; c) segment analysis for thematic allocation of each plot in the segment; d) preparation of the land use map by incorporating each segment in the automatic classification; e) transmission to the current situation unit; f) preservation of the results. Stages b) and c) are carried out using the ORCA software owned by the Commission.

2.5.2.6 Current situation

The purpose of the current situation task is to estimate the acreages of each of the 17 crops of interest at European level, every two weeks from April onwards. The estimate is based on extrapolation of the data obtained by processing a maximum of four images per site. "Current situation system" software and some other auxiliary packages are used in this phase.

2.5.2.7 *Training*

Training is divided into two stages. The first comprises initial training, to establish the production team. It is followed by on-the-job training to meet a need to develop the production tools and therefore to modify operating methods.

2.5.2.8 *Maintenance*

Maintenance ensures that all the data processing equipment involved in the production chain and provided by the entity responsible for image processing and estimate production is available at all times.

2.5.2.9 *Internal project control*

This activity is meant to ensure that the production chain operates efficiently at all times, that deadlines are met and that the set quality standards are maintained during the various estimate preparation phases.

2.5.2.10 *Reports*

The main product of this activity is the supply of estimates of changes in crops of interest for the Commission. These estimates are delivered during the season and in real time, in various forms: tables by geographical level, tables by crop, reports of the current situation regarding acreages, etc.

2.5.2.11 *Product delivery*

This activity consists in providing the Commission almost instantaneously with all auxiliary data ahead of the statistical results produced by the processing chain. This information represents a vast, harmonised historical database which can be used for other research or other applications.

2.5.2.12 *Cost of image processing and production chain for estimates*

Table 4 sets out expenditure on image processing during the operational phase. NB: in 1994 and 1995 the processing concerned the 53 sites of the EU of 12, as the current 60 sites did not form part of the operational phase until 1996.

Table 4 - Breakdown of expenditure on "Processing"

	1994	1995	1996	1997	1998
PRODUCTION	1,280,170	1,081,700	1,144,841	612,624	621,399
Project execution and management	90,000	90,000	62,474	64,172	66,007
Project launch	---	---	552,919	---	---
Preparations for the season	123,300	123,300	106,082	109,135	106,033
Collection and preliminary processing of satellite data	49,500	49,500	32,205	33,026	33,914
Interpretation of satellite data	388,800	388,800	218,967	225,222	231,959
Current situation	76,500	76,500	92,474	108,797	111,483
Training	---	---	31,688	---	---
Maintenance	50,400	50,400	48,031	72,272	72,003
Equipment	501,670	303,200	---	---	---
PROJECT CONTROL	---	---	64,361	66,157	60,689
REPORTS	26,000	26,000	32,895	33,395	33,957
PRODUCTS	17,300	17,300	19,516	20,084	20,695
ISPRA EXPERT	---	---	96,194	98,506	100,874
TOTAL	1,323,470	1,125,000	1,357,807	830,767	837,614

For the years 1994 and 1995 the Commission had used the contractual framework of the pre-operational phase, but from 1996 onwards these activities were entrusted to companies outside the Commission, selected by tendering procedures based on free competition. The higher expenditure in 1996 was due to the launch activities described earlier.

2.5.3 Software maintenance

Produced at the request of the Joint Research Centre, the GRIPS and ORCA software was supplied to the JRC in October 1994 and August 1995 respectively. The GRIPS software is used for the radiometric and geometric rectification of the SPOT and LANDSAT images. The ORCA software is used to back up photo interpretation in Activity B. Recently, GRIPS was adapted to process IRS/LISS images incorporated in Activity B at the start of 1998.

The purpose of maintenance is to ensure that these two software packages operate properly in the processing and estimate production phases. It is entrusted to a specialist firm.

There are two types of maintenance: corrective and adaptive. The former is intended to correct operating anomalies either in the *hardware* or in the operating system. The latter covers research and the implementation of any kind of modification to the *software* requested by the users. ORCA also uses two software packages, CLIPS and ARKEMIES, in its development and operation; the licences are owned by external firms. Use of these two packages by ORCA entails licensing and maintenance costs.

Table 5 - Cost of using the GRIPS and ORCA software

	1996	1997	1998*
GRIPS software			
Corrective maintenance	13,415	23,000	23,000
Adaptive maintenance	8,200	20,664	48,186
GRIPS total	21,615	43,664	71,186
ORCA software			
Arkemie licence	18,175		
Clips licence	10,935		
Computer configuration	32,730		
Corrective maintenance	19,497	55,000	55,000
Maintenance of the computer configuration		3,125	3,125
Adaptive maintenance		52,869	23,049
Corrective maintenance (ARKEMIE and CLIPS)		9,000	9,000
Total ORCA	81,337	119,994	90,174
Total GRIPS and ORCA	**102,952**	**163,658**	**161,360**

2.5.4 Ground surveys

As already stated, the images alone are not enough for reliable determination of the various types of land use. We have also mentioned the need to correct the results of the automatic image classification and the importance of establishing a well-documented historical database for the segments forming part of each site. This means that we need auxiliary information of the "ground survey" type. These surveys are conducted either by private firms or by statistical authorities of the Member States, selected on the basis of open tendering. The table below gives detailed information on the cost of ground surveys per annum and per Member State.

Table 6 - Cost of ground surveys in ECU (1994-1998)

Sites in:	1994*	1995*	1996	1997	1998
Austria	--	--	25,800	22,980	28,157
Benelux	14,400	14,270	8,500	14,250	10,340
Denmark	35,650	33,630	34,265	23,330	25,777
Finland	--	--	28,960	27,563	30,461
France	135,250	75,063	77,458	65,650	56,790
Germany	104,132	99,315	101,739	78,173	78,538
Greece	24,600	21,900	22,000	20,500	18,600
Ireland	(1)	(1)	(1)	13.440	11.670
Italy	83,821	74,998	49,940	48,760	48,950
Portugal	20,600	20,550	18,300	16,682	17,000
Spain	89,409	107,363	113,130	85,233	76,620
Sweden	--	--	53,734	51,000	44,500
United Kingdom	46,991	42,830	48,140	36,032	33,885
Total	**554,853**	**489,919**	**581,966**	**503,593**	**481,288**

(1) The costs are included in those of the United Kingdom; (*) 53 sites

2.5.5 Financial management

Moving on to the operational phase has also meant changes to the management of Activity B. Apart from 1994, which is a transitional year between the research phase and the operational phase of the project, Activity B was financed mainly

by appropriations available under heading B2-513 of the general budget («Restructuring of agricultural survey systems »). However, some of the ground surveys were conducted using appropriations available under heading B6-792 («Activities providing scientific and technical support for Community policies on a competitive basis »).

During this phase, several measures were initiated to reduce the operating costs of Activity B while keeping within the limits imposed by the methodology. These efforts focused on three main areas where it was considered possible to cut costs: image purchase, processing and ground surveys. The table below shows the changes in the average cost per site during 1994 to 1998:

Table 7 - Changes in the average cost per site (ECU thousands)

	1994	1995	1996	1997	1998
Processing	25.0	21.2	22.6	13.8	14.0
Images	11.9	12.0	11.1	10.9	11.0
Ground surveys	10.5	9.2	9.7	8.4	8.0
Total per site	47.4	42.4	43.4	33.2	33.0

As we can see, the average cost per site dropped from ECU 47,400 in 1994 to ECU 33,000 in 1998, a reduction of around one third. The cut in costs was greatest for processing (down 44.4%) and more modest for images (down 12.6%) and ground surveys (down 23.8%).

2.6 Results obtained and error analysis

The results of the acreage estimates obtained by Activity B are set out in the MARS bulletin, published monthly from January to October by the Joint Research Centre. This Bulletin also contains an examination of the agro-meteorological situation and predicted yields for the main crops. This bulletin is normally prepared very quickly (within a few days of the latest images being obtained) and forwarded promptly to the Commission departments concerned, as well as to members of the Eurostat working party on "Vegetable product statistics", and to a number of experts in the various Member States.

Each year, in accordance with Council Decision 94/753/EC, the Commission also submits to the Standing Committee on Agricultural Statistics a report on the implementation of that Council decision. When this report is discussed by the working party on "Vegetable product statistics", the Commission also has the opportunity to present and discuss the results of Activity B and the procedures for conducting that activity. Annexes 1 to 4 show all the results of Activity B compared to the Eurostat official statistics. The error analysis for 1994 to 1997 is outlined below.

This analysis is based on a comparison of the acreage estimates for the various crops as obtained from Activity B against the Eurostat official statistics (generally available on 15 May in the following year on the CRONOS database). Although this approach is not, strictly speaking, a genuine validation of the results of Activity B, since even the official statistics are not error-free, it is nevertheless useful to have an

idea of the discrepancies between the two sources and hence the margin of error in the acreage estimates produced by Activity B.

The table below gives a general view of the average percentage deviations between the monthly estimates obtained by Activity B and the official figures for 1994 to 1997 (the figures for 1998 were not yet available when this report was written).

Table 8 - Average monthly deviation of Activity B between 1994 and 1997 (%)

	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	Average
Cereals	1.0	1.2	1.4	1.1	1.2	1.0	1.0	**1.1**
Wheat	0.9	1.1	1.8	1.8	1.8	1.6	1.6	**1.5**
Common wheat	1.0	1.6	2.7	1.9	1.8	1.7	1.7	**1.8**
Durum wheat	3.0	4.0	3.6	3.9	3.9	3.9	3.8	**3.7**
Barley	2.7	2.9	3.1	2.4	2.4	2.2	2.2	**2.6**
Maize	3.8	2.7	4.1	4.9	4.9	4.9	4.7	**4.3**
Colza	8.3	11.7	12.5	14.4	13.5	12.3	12.3	**12.1**
Sunflower	16.0	10.8	7.3	6.9	6.7	6.3	6.9	**8.7**
Rice	9.4	12.2	11.7	9.3	9.2	7.9	7.9	**9.7**
Beet	5.7	6.3	4.0	3.8	5.6	4.9	4.6	**5.0**

The last column in Table 8 shows the average error over the whole period for the main crops. For cereals as a whole, we find that the average error is 1.1% but it increases to 1.8% in the case of common wheat, 2.6% for barley, 3.7% for durum wheat and 4.3% for maize. The error is even greater for sunflower (averaging 8.7%) and colza (12.1%), and is also very marked in the case of beet (5.0%) and crops which are poorly represented at the sites such as rice (average 9.7%). Moreover, we must not lose sight of the fact that, even though the margin of error is smaller for cereals than for other crops in percentage terms, a 1.1% error nevertheless represents an area of around 400,000 hectares, roughly equivalent to 2.5 million tonnes of cereals. Even this margin of error may be considered excessive, given the requirements concerning the management of this market.

Over the years there has admittedly been a slight improvement in the margin of error for winter crops. However, the estimation error is still too high for spring crops and oilseeds.

2.7 Evaluation of the action

The report on Activity B at the end of phase 2 of the MARS project presents both strengths and weaknesses. The strengths may be summarised as follows.

- It is technically possible, via remote sensing, to obtain rapid estimates of changes in the acreage of the main crops at European level. This can be done by monitoring a relatively small sample of sites, at least for the main cereal crops.

- In terms of introducing technological innovation and setting up more modern systems for collecting agricultural statistics, the MARS project and Activity B in particular are certainly a success. Apart from the remote sensing applications mentioned above, which were developed to meet the needs of the Commission, there are currently many applications, not only in several EU Member States but

also in some East European countries which are aiming to improve national statistical systems by using the lessons learnt from the MARS project.

- The whole technical chain of Activity B, data acquisition and analysis, in relation to operational production systems and results, is also a success in so far as it has made the information sought available within a very short time after acquisition of the basic data (satellite images).

- The establishment of Activity B as part of the MARS project has generated other applications outside agricultural statistics, such as those relating to supervision of the acreages declared by farmers under the CAP, and has shown that new applications are also possible, e.g. in monitoring the condition of forests or the agri-environmental situation.

In addition to these strengths, the MARS project and more particularly Activity B are still encountering certain limits to the application of remote sensing to agricultural statistics as regards estimating acreages. The weaknesses may be summarised as follows:

- The sample used does not yield reliable estimates at national level, even for the largest countries.

- Although Activity B permits a correct overall assessment of the change in cereal acreages as a whole at an earlier date than the official statistics, it performs less well in the case of more specific crops (beet, maize, colza, etc.). This is partly because the sample used offers a less satisfactory level of representation for individual crops, and partly because in certain cases the different crops are difficult to separate. Furthermore, remote sensing cannot identify the destination of the product or the purpose for which it is grown: common wheat or durum wheat, grain maize or fodder maize, food or non-food colza, subsidised fallow land (set aside) or land lying fallow under a system of crop rotation, etc.

- While the initial acreage estimates supplied by Activity B, i.e. those available at the beginning of May or June, are generally earlier than the official statistics, they have not yet been stabilised and are not very reliable, given the small number of images and sites on which they are based and the greater difficulty in separating the different crops at this stage. It is not until the end of June that the information becomes relatively stable. Nevertheless, at that stage the spring crop acreages are still not easy to record by remote sensing.

- The images are still expensive, despite some savings made in recent years, and it has not been possible to achieve any significant reduction in the cost except for Eastern Europe, where there is less demand for satellite images. This constraint, together with the conflicts between programming and acquisition, considerably restricts any scope for increasing the number of sites in order to improve the representation of crops of interest and thus reduce the margin of error in the estimates.

- Despite the adaptations made over the years (e.g., better integration of ground surveys and remote sensing estimates), the system suffers from excessive rigidity

in the face of the possible changes in the location of crops and the innovations which one would like to introduce (for instance, Activity B did not detect the relocation of colza production in 1994 following the CAP reform).

2.8 Conclusions

In the light of the foregoing, it does not seem desirable simply to renew Activity B of the MARS project using the same methods and actions as in phase 2. Despite the improvements made in recent years, with the scientific and financial resources currently available, the acreage estimates produced by remote sensing with the methodology hitherto applied are not entirely satisfactory, either in terms of lead times or as regards reliability, particularly at the level of the specific crops of interest to those administering the Common Agricultural Policy.

Representation could certainly be improved by increasing the number of sites, but the costs would then outweigh the benefits (e.g. the total cost of Activity B for 100 sites is around ECU 5 million in the first year and almost ECU 4 million once it is up and running. It is uncertain whether 100 sites would be sufficient to achieve satisfactory representation). Finally under current conditions, the scope for reducing the cost of images and ground surveys seems relatively limited.

However, it does not seem desirable to abandon Activity B, particularly on account of the following:

- the Commission has devoted substantial financial resources to this subject in order to gain a unique technological lead in this field at both European and world level; the applications may not yet have been fully exploited;

- the needs which gave rise to the project (to provide an independent means of producing early estimates of areas and yields) still exist;

- to abandon Activity B would probably jeopardise other potential applications in different areas of agricultural statistics (e.g., monitoring the condition of forests, agri-environmental indicators, etc.);

- the JRC ought to maintain a technically skilled team to provide technical support for the Commission, or for isolated analyses which might be needed (e.g. analysis of the impact of drought on harvests, etc.).

Taking account of these various points, the JRC should be instructed to examine alternative methods or significant improvements to the current approach, with the aim of increasing the reliability and lead times of the area estimates while keeping within the bounds of the current financial constraints.

Work on this subject began in 1997 and is intended to continue after 1998. It covers various alternative methodological approaches including major modifications to the conventional approach to remote sensing, new sampling methods, etc. This research needs to continue for several years before we can move on, if appropriate, to a new operational phase. If this work leads to alternatives to the current method which

prove satisfactory in terms of data reliability, lead times and costs, we should ultimately consider funding them out of the Commission's operating appropriations.

PART II - Activities for development

3. ACTIVITY C: THE ADVANCED AGRICULTURAL INFORMATION SYSTEM

Activity C is divided into 4 sub-objectives:

- C.1: to complete current development concerning the establishment of vegetation condition indices.
- C.2: to set up yield prediction models (transition to the operational stage of agro-meteorological models).
- C.3: to create an integrated agricultural information system at European Union level by combining the information obtained from Activity B and Activities C.1 and C.2.
- C.4: to examine how and under what conditions an integrated system can be set up at national and regional level.

Below is a brief description of the work done during phase 2 of the MARS project on these various activities.

3.1 C.1 Vegetation condition indices

Continuing the work of phase 1, this action aimed to set up an operational chain to process and store the daily images of the NOAA-AVHRR meteorological satellite and to extract data on the condition of vegetation. The phase 2 work focused mainly on the following aspects:

- Setting up a receiving station at the JRC (task completed).
- Installing *hardware* capable of processing more than one image at a time (task completed).
- Parametric maintenance of the SPACE software for preliminary image processing (permanent task).
- Installing the SPACE system on PC (task completed).
- Improving filtering and synthesis techniques for the NDVI (Normalised Difference Vegetation Index)[5] (task completed but implementation in progress).
- Improving the derived thematic cartography for qualitative use of the NDVI in analysis of the current situation (task completed).

[5] This index indicates the photosynthesis activity of plants.

- Developing numerical statistical models for the yield forecasts derived from the NDVI (task in its final test and validation year).

- Developing a model to estimate biomass on the basis of the NDVI (study completed and now being applied).

The production chain provides a cartographic view of the main factors disrupting the farming year: drought, delayed or early plant development, etc.

Future policy

On the basis of the results and validations during 1998 it will be possible to assess the extent to which this sub-objective can be considered operational. The same approach will be applied in future to the VEGETATION sensor launched in March 1998. The advantage of this European sensor is that it permits easier parametric management of the images to extract the vegetation indices. The sensor was in fact designed from the start for the observation and monitoring of small-scale vegetation, and not for meteorological observations, as was the NOAA-AVHRR.

3.2 C.2 Yield prediction models

Yield prediction is one of the key objectives assigned to the project. This particularly concerns the yields of the main annual crops, but also those of the main perennial crops such as vines and olives.

The yield prediction models developed are based on the agro-meteorological simulation models incorporated in the CGMS (Crop Growth Monitoring System) designed, applied and improved by the JRC during phases 1 and 2.

To develop the model it was necessary to establish a data base on soils, climate, plants and yields. This data base was updated year by year and extended during phase 2.

As planned in phase 1, the yield predictions are obtained from a statistical correlation between the historical yield series and the historical series of quantitative parameters obtained from the following sub-models:

- A potential evapotranspiration sub-model.
- A global radiation sub-model.
- A sub-model for the spatial interpolation of meteorological data.
- A sub-model for usable water reserves for each crop.
- A sub-model for the physiological growth of crops.

Each of these sub-models and the associated database were improved by specific research and actions, in particular:

3.2.1 *Meteorological data*

As in phase 1, historical meteorological data were acquired over a fairly long period of 25 to 30 years. The data collected are those normally available on the GTS network (Global Telecommunications System) and used as input data for the models or sub-models. These are daily data which concern more particularly:

- rainfall,
- temperature (maximum, minimum),
- water vapour pressure or relative humidity,
- average wind speed,
- hours of sunshine or cloud cover.

In phase 2 the number of stations with historical records was doubled to around 700 (in the extended area of the European continent and the Maghreb region, see Activity D). Other improvements made were as follows:

- Improvements to the network of meteorological stations used (700 in phase 1, of which 350 had historical records and 350 only current data, 2000 in phase 2 including 700 with historical records). (Task completed).
- Improvement in data interpolation techniques (study completed and in experimental phase).
- Thematic improvement in derived products such as the production of maps showing meteorological extremes, the risk of frost (on-going task).
- Improvement in the algorithms for calculating parameters such as global radiation (study completed and in experimental phase).
- Improvements to the presentation of results incorporated in MARS Bulletins (Activity C.3).

3.2.2 *Pedological data and agronomic parameters:*

The final data used in the statistical models and in connection with Activity C.3 are as follows:

- abnormal meteorological conditions,
- development indices for the ten-day period and since the beginning of the vegetation cycle, namely:.biomass; seed production; water reserves; phenological stage; water balance; excess water; leaf index.

The main crops of interest are: wheat, barley, seed maize, colza, sunflower, sugar beet, potatoes, peas and protein beans. The principal improvements made in phase 2 are as follows:

- Introduction of information from the soil map of the European Soil Bureau (JRC), (task completed on the EU of 15).

- Maintenance of the agronomic parameters relating to each crop (sowing date, harvest, phenological dates, etc.). (Task in progress).

- Thematic extension of the agro-meteorological model to include vines and olives. This gave rise to a separate project known as OLIWIN 1 and 2. The results were incorporated in the MARS bulletin in 1997 and 1998. Validation of the results will follow in 1998.

- Improvements to the presentation of the results incorporated in the MARS Bulletins (Activity C.3).

3.2.3 Yield prediction:

- Improvement and validation of statistical models for the calibration of yield data obtained from the model (task still in progress in 1998). An initial study on the accuracy of the results was published by the JRC.

3.2.4 Information technology:

- Improvement in access to data and interfaces with users.

- Installation on PC of the CGMS Model.

The *Support Group for Agrometeorology (SuGrAm)*, set up in 1990, made it possible to validate the network of meteorological stations and the interpolation method, as well as the sub-models for calculating potential evapotranspiration and global radiation. This group is co-ordinated by the World Meteorological Organisation. During phase 2, this group formed an essential scientific reference point for continued improvements to the CGMS and validation of all kinds of associated results.

3.3 C.3 Integrated agricultural information system and MARS bulletin

All data relating to the monitoring of vegetation, growth simulation, monitoring of meteorological extremes and auxiliary data (timetable of field work, knowledge base concerning crops, etc.) available under the MARS project are combined in a "current situation" analysis to establish the expected yields for the main crops at national and European level.

The current situation task is carried out by the JRC at the end of each month during the farming season.

On the basis of the current situation analysis, the numerical indications obtained from the various statistical models are validated and published in the MARS bulletin, which represents the end product of this activity.

The acreage estimates obtained by Activity B are also incorporated in the MARS bulletin, as supplied by the external contractor responsible for this activity. The exchange of information between Activity B and Activities C.1 and C.2 has proved useful in explaining the results obtained.

Since 1994, 31 MARS bulletins have been published and 6 (plus a fax version) are planned for 1998. The print run averages 300 copies. They are circulated to the Commission's Directorate General for Agriculture (DG VI) and the other interested DGs, Eurostat, the Member States (representatives of delegations in the Eurostat Working Party on "Plant product statistics") and to other international bodies concerned such as the FAO. The following are some of the improvements made in recent years:

- In 1997 the bulletin included the results of the OLIWIN project, i.e. the results of the analysis of olives and vines.

- From the end of 1996 the results of Activity D (prediction of harvests outside the Community) were also included in the bulletin. With these data it was possible to produce initial experimental predictions for wheat yields in central and east European countries (PHARE and TACIS countries), Turkey, and the Maghreb countries (see Activity D).

- An internal report was produced which examined the error in analysis of the current situation and the various associated statistical models. The results show that the forecasts are earlier and the error is smaller than for other available sources.

- In 1998, extension of the model to include countries bordering on the EU of 15 (countries covered by the PHARE and TACIS programme) and the Maghreb countries will be completed with the introduction of other crops of interest.

Table 9 - 1997 results for the EU of 15

		April	May	June	July	Aug.	Sept.	Oct.	Eurostat*
Cereals	Estimated yield	5.43	5.44	5.46	5.41	5.42	5.42	5.41	5.39
	% deviation	*0.64*	*0.79*	*1.24*	*0.33*	*0.51*	*0.39*	*0.36*	
Total wheat	Estimated yield	5.71	5.7	5.72	5.69	5.63	5.63	5.63	5.52
	% deviation	*3.50*	*3.20*	*3.60*	*3.10*	*2.00*	*2.00*	*2.00*	
Common wheat	Estimated yield	6.4	6.4	6.5	6.4	6.4	6.4	6.4	6.24
	% deviation	*2.70*	*3.10*	*4.00*	*3.30*	*2.30*	*2.30*	*2.30*	
Durum wheat	Estimated yield	2.7	2.5	2.4	2.4	2.4	2.4	2.4	2.26
	% deviation	*18.90*	*11.30*	*6.20*	*7.90*	*4.70*	*4.70*	*4.70*	
Barley	Estimated yield	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.41
	% deviation	*0.30*	*2.50*	*2.60*	*1.60*	*1.50*	*1.60*	*1.60*	
Seed maize	Estimated yield	8.4	8.4	8.5	8.5	8.6	8.6	8.5	8.95
	% deviation	*-6.1*	*-6.1*	*-5.2*	*-5.5*	*-3.5*	*-4.2*	*-4.5*	

* Final figures in May 1998

3.4 C.4 Integrated system at national and regional level

Following various contacts with a number of EU Member States, the systems available under the MARS project were transferred and adapted to the real situation in the various regions.

Under the Hydre project and its continuation, Pop-SICILY, the agro-meteorological system was transferred to the local authorities and adapted for the monitoring and statement of regional water resources. The regions taking part were Sicily and Sardinia in Italy, Languedoc-Roussillon in France and Andalucia in Spain.

Via co-operation on request, the agro-meteorological system was adapted and transferred to the Finnish statistical service.

4. ACTIVITY D: MONITORING AND PREDICTION OF HARVESTS OUTSIDE THE COMMUNITY

The purpose of Activity D was to perfect and extend methods developed by the other MARS project activities to countries bordering on the EU, particularly central and east European countries and the Maghreb region, in order to predict harvests in those countries. The main developments in this field were as follows:

- In 1996 a first bulletin was published which, by way of experiment, included the first extensions of the CGMS model, now known as System D. This bulletin referred to the agro-meteorological aspects of wheat growing in the countries mentioned.

- In 1997 the analysis was incorporated in Activity C.3 and the first yield and production forecasts were supplied for 12 countries outside the EU of 15, including Russia, Ukraine, the PHARE programme countries and the Maghreb region, plus other qualitative information on harvest trends in 14 other countries.

- In 1998 the results will be extended to other crops of interest such as barley and maize.

5. ACTIVITY E: APPLICATION OF NEW METHODS OR SENSORS

5.1 Pilot project for uses of microwave images in estimating acreages

In 1996 a pilot project was launched on the incorporation of microwave (radar) images obtained from the ERS 1 and 2/SAR satellites into the system of quick estimates of agricultural acreages. The advantage of using radar is that images can be obtained even in cloudy conditions. Also the information obtained is related to the geometry and ruggedness of the targets rather than the radiometric content, as in the case of optical sensors. This offers the advantage that the images can be correlated with crop development sooner than with optical sensors. Research on the use of radar has led to a pilot application spread over two years:

- 1996: a larger-scale feasibility study to introduce radar images recorded by the European satellite ERS-2 was completed. The application simulated an Activity B at a number of sites in northern Europe. In view of the encouraging results, it was possible to move on to the next phase.

- 1997: the application was extended to all 60 sites of Activity B. The project aimed to improve the lead times and accuracy of agricultural acreage estimates by synergy between optical/infra-red data obtained during Activity B of the MARS project and the ERS/SAR radar data. In the project, almost 300 radar images were obtained at the 60 Activity B sites during the winter of 1996 and the spring of 1997. Acreage estimates were obtained for the main groups of crops as early as January.

The acreage estimates derived by ERS/SAR radar for the 1997 seasons were compared with those of Activity B (which uses only optical images) and the results of ground surveys. The results of the two pilot studies showed that the ERS/SAR data for the autumn, winter and spring can produce useful information for estimating acreages of crops sown. However, the application gives better results in areas composed of large fields with greater uniformity in terms of farming practices and soil texture and structure. In more disparate areas, the results have to be integrated with auxiliary information on the variables mentioned. Additional research has shown that, by the combined use of optical data and ERS/SAR radar, it is possible to complete chronological optical image series which are incomplete owing to cloud problems.

Future policy

New sensors with different characteristics will be available in the near future. These could create scope for improving the MARS project methods. The use of all-weather radar, sensitive to geometric variations in the terrain, could bring the acreage estimates forward to before the spring.

A pilot project using ERS/SAR radar has also shown the potential effectiveness of using remote sensing to speed up winter estimates.

The new very high resolution sensors, available within the next few years, should subsequently enhance the value of the methodology by reducing the uncertainty of discrimination between certain crops.

5.2 Re-engineering of Activity B (REACT_B)

In 1997 a project for examining all possible improvements to the current methods of applying remote sensing to agricultural statistics (e.g. improvement in classification methods) was launched. This project was dubbed REACT_B (i.e. re-engineering of Activity B).

The REACT_B project was launched in January 1997 with a list of users' requirements. These requirements are the benchmark for analysing the performance of the current approach.

The plan of work provides for updating the whole chain of Activity B:

- image acquisition,
- image processing,
- image interpretation and classification.

However, the accent will be on sampling in conjunction with the use of satellite mini-images rather than entire scenes, and on liaison with other MARS project activities.

A statistical study has shown that it is feasible to use sites smaller than the current ones. However, operational use has yet to be demonstrated.

An increase in the number of sites should make the sample more representative as regards crops of interest and improve the estimate accuracy. The two aspects, « representativity » and « accuracy » are critical for the needs of users. The various sampling scenarios are now being evaluated with the image suppliers to check the technical feasibility of such an approach.

A large-scale exercise will produce data for one EU region (the Bavarian site, NUTS II). For this test zone, all ancillary data have been acquired and incorporated in a geographical information system. Images produced by operational sensors (SPOT, LANDSAT, IRS-1C and ERS/SAR) have been obtained for comparative analysis of the performance of the various classifications. The tests are based on comparison with the results of a ground survey covering the whole zone.

On the basis of this feasibility study and the data obtained, the techniques and methods used will be improved as part of a detailed evaluation in 1998. Operational tests in parallel with Activity B will be conducted at the sites concerned. The RADARSAT and SPOT 4 satellites, and possibly the RESOURS satellite, will provide other information of use to the study.

One very important element of the project is the evaluation of the cost/benefit ratio, which will have to be acceptable before any operational system is implemented.

5.3 The aeropalynological model

This research activity was completed in 1997. The purpose of this project was to supply grape harvest predictions (or wine production predictions) based on the conditions during flowering of the vines. These conditions were monitored in terms of quality and quantity of plant fertilisation using a pollen sensing method.

By using a reliable and reproducible technique for sampling and analysing atmospheric pollen flows it is possible to produce early harvest predictions about three months before the grapes are picked. However, it is necessary to obtain an expert agronomist's opinion to validate the laboratory results used.

The proposed method can be used to produce valid predictions both for the zones sampled and at national and Community level. At local level, the method provides a totally satisfactory answer in around 50% of situations. The effect of post-flowering conditions, which can greatly modify the potential present at the time of flowering, is the main cause of the deviations found. It is therefore essential for the first early predictions obtained by pollen analysis using agro-meteorological models to be updated during the season. But there are also - often clearly identified - profiles in which this method cannot be used. On a national scale, the results are considered satisfactory where an adequate network of pollen sensing posts is established.

From the pattern of the pollen emission curve it is also possible to identify precisely the dates of the flowering period and, via an overall assessment of phenological homogeneity in the zone sampled, to arrive at an initial approximation of the vintage's potential.

The activity was conducted with the support of CEMAGREF, Montpellier University and various national agencies in the countries considered.

In conclusion, these methods can now be considered operational, but they can continue only if they are taken over by national operational entities. The JRC has arranged this transfer, but success will depend on the presence of a body which is both technically competent and able to afford the cost of the operation.

6. CONCLUSIONS CONCERNING THE ACTIVITIES BEING DEVELOPED

After two five-year cycles of research, significant results have been obtained:

- The agro-meteorological part (low-resolution model and satellite data) can be considered satisfactory and operational, even though there is still scope for improvement. The results are available at European, national and regional level.

- A number of limitations in Activity B, particularly representativity at national level and for certain products, seem capable of being overcome by the use of new sensors and new sampling methods, but their operational use has yet to be demonstrated.

- Some methods, such as the aeropalynological model, can be considered only if they are taken on by national authorities.

ANNEX 1

MARS ACTIVITY B ACREAGE ESTIMATES FOR THE MAIN CROPS AND DEVIATIONS IN RELATION TO EUROSTAT (1994): EUR-12

1994		APRIL		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		Eurostat	Eurostat (000 ha)		Aver. deviation	
		1000 ha	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	%	1994	1993	*1000 ha*	%
Cereals	**estim.**	**32371,9**	**0,3**	**32630,1**	**1,1**	**32759,2**	**1,5**	**32436,4**	**0,5**	**32436,4**	**0,5**	**32404,1**	**0,4**	**32404,1**	**0,4**	**-1,18**	**31893,20**	**32275,03**		
	deviat.	478,7	1,5	736,9	2,3	866,0	2,7	543,2	1,7	543,2	1,7	510,9	1,6	510,9	1,6				**613,44**	**1,92**
Total wheat	**estim.**	**15418,9**	**1,5**	**15531,2**	**2,3**	**15514,1**	**2,1**	**15414,8**	**1,5**	**15417,6**	**1,5**	**15408,3**	**1,5**	**15420,5**	**1,5**	**0,62**	**15281,42**	**15187,98**		
	deviat.	137,4	0,9	249,8	1,6	232,7	1,5	133,4	0,9	136,2	0,9	126,9	0,8	139,0	0,9				**172,05**	**1,13**
Common wheat	**estim.**	**12408,7**	**0,9**	**12519,4**	**1,8**	**12556,3**	**2,1**	**12470,2**	**1,4**	**12470,2**	**1,4**	**12457,9**	**1,3**	**12470,2**	**1,4**	**-0,43**	**12244,69**	**12298,03**		
	deviat.	164,0	1,3	274,7	2,2	311,6	2,5	225,5	1,8	225,5	1,8	213,2	1,7	225,5	1,8				**238,29**	**1,95**
Durum wheat	**estim.**	**3014,2**	**4,3**	**3017,1**	**4,4**	**2962,2**	**2,5**	**2947,7**	**2,0**	**2950,6**	**2,1**	**2953,5**	**2,2**	**2953,5**	**2,2**	**5,08**	**3036,73**	**2889,95**		
	deviat.	-22,5	-0,74	-19,6	-0,6	-74,5	-2,5	-89,0	-2,9	-86,1	-2,83	-83,2	-2,7	-83,2	-2,7				**71,33**	**2,35**
Barley	**estim.**	**10182,0**	**-0,1**	**10222,7**	**0,3**	**10253,3**	**0,6**	**10141,2**	**-0,5**	**10141,2**	**-0,5**	**10141,2**	**-0,5**	**10141,2**	**-0,5**	**-4,71**	**9712,43**	**10192,17**		
	deviat.	469,5	4,8	510,3	5,3	540,9	5,6	428,8	4,4	428,8	4,4	428,8	4,4	428,8	4,4				**464,28**	**4,78**
Maize	**estim.**	**3746,9**	**-0,5**	**3618,9**	**-3,9**	**3709,2**	**-1,5**	**3615,1**	**-4,0**	**3615,1**	**-4,0**	**3554,8**	**-5,6**	**3562,4**	**-5,4**	**-2,49**	**3671,99**	**3765,72**		
	deviat.	74,9	2,0	-53,1	-1,4	37,3	1,0	-56,9	-1,5	-56,9	-1,5	-117,1	-3,2	-109,6	-3,0				**77,49**	**2,11**
Colza	**estim.**	**2374,2**	**9,5**	**2341,6**	**8,0**	**2283,1**	**5,3**	**2333,0**	**7,6**	**2335,1**	**7,7**	**2335,1**	**7,7**	**2333,0**	**7,6**	**14,97**	**2492,82**	**2168,18**		
	deviat.	-118,7	-4,8	-151,2	-6,1	-209,7	-8,4	-159,9	-6,4	-157,7	-6,3	-157,7	-6,3	-159,9	-6,4				**161,14**	**6,46**
Sunflower	**estim.**	**3310.7**	**2,0**	**3180,9**	**-2,0**	**2771,9**	**-14,6**	**2486,3**	**-23,4**	**2483,0**	**-23,5**	**2512,2**	**-22,6**	**2502,5**	**-22,9**	**-10,43**	**2907,27**	**3245,80**		
	deviat.	403,4	13,9	273,6	9,4	-135,4	-4,7	-421,0	-14,5	-424,2	-14,6	-395,0	-13,6	-404,8	-13,9				**365,09**	**12,56**

estim. = areas (x 1000 ha) and % change in relation to previous year estimated by Activity B
deviat. = difference between the Activity B estimate and the Eurostat official figures
% = change in area in relation to previous year
EUROSTAT final figures in May 1998 (x 1000 ha)

ANNEX 2

MARS ACTIVITY B ACREAGE ESTIMATES FOR THE MAIN CROPS AND DEVIATIONS IN RELATION TO EUROSTAT (1995): EUR-12

1995		APRIL		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		Eurostat	Eurostat (000 ha)		Aver. deviation	
		1000 ha	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	%	1995	1994	*1000 ha*	%
Cereals	**estim.**	**32850,0**	**3,0**	**32499,2**	**1,9**	**32467,3**	**1,8**	**32307,8**	**1,3**	**32275,9**	**1,2**	**32339,7**	**1,4**	**32339,7**	**1,4**	**2,65**	**32738,60**	**31893,20**		
	deviat.	111,4	0,3	-239,4	-0,7	-271,3	-0,8	-430,8	-1,3	-462,7	-1,4	-398,9	-1,2	-398,9	-1,2				**350,76**	**1,07**
Total wheat	**estim.**	**15780,4**	**3,3**	**15712,0**	**2,8**	**15767,6**	**3,2**	**15569,5**	**1,9**	**15569,5**	**1,9**	**15618,6**	**2,2**	**15609,3**	**2,1**	**4,31**	**15940,59**	**15281,42**		
	deviat.	-160,1	-1,0	-228,6	-1,4	-173,0	-1,1	-371,1	-2,3	-371,1	-2,3	-322,0	-2,0	-331,2	-2,1				**291,95**	**1,83**
Common wheat	**estim.**	**12820,2**	**4,7**	**12710,0**	**3,8**	**12783,5**	**4,4**	**12648,8**	**3,3**	**12648,8**	**3,3**	**12697,7**	**3,7**	**12685,5**	**3,6**	**4,57**	**12803,86**	**12244,69**		
	deviat.	16,3	0,1	-93,9	-0,7	-20,4	-0,2	-155,1	-1,2	-155,1	-1,2	-106,1	-0,8	-118,4	-0,9				**108,81**	**0,85**
Durum wheat	**estim.**	**2957,8**	**-2,6**	**3000,3**	**-1,2**	**2982,1**	**-1,8**	**2918,3**	**-3,9**	**2918,3**	**-3,9**	**2918,3**	**-3,9**	**2921,3**	**-3,8**	**3,29**	**3136,74**	**3036,73**		
	deviat.	-179,0	-5,71	-136,4	-4,4	-154,7	-4,9	-218,4	-7,0	-218,4	-6,96	-218,4	-7,0	-215,4	-6,9				**194,25**	**6,19**
Barley	**estim.**	**9935,8**	**2,3**	**9731,9**	**0,2**	**9741,6**	**0,3**	**9858,1**	**1,5**	**9819,3**	**1,1**	**9838,7**	**1,3**	**9838,7**	**1,3**	**0,99**	**9808,79**	**9712,43**		
	deviat.	127,0	1,3	-76,9	-0,8	-67,2	-0,7	49,3	0,5	10,5	0,1	29,9	0,3	29,9	0,3				**66,45**	**0,68**
Maize	**estim.**	**3532,4**	**-3,8**	**3668,3**	**-0,1**	**3642,6**	**-0,8**	**3580,2**	**-2,5**	**3539,8**	**-3,6**	**3539,8**	**-3,6**	**3569,2**	**-2,8**	**-0,66**	**3647,74**	**3671,99**		
	deviat.	-115,3	-3,2	20,6	0,6	-5,1	-0,1	-67,6	-1,9	-107,9	-3,0	-107,9	-3,0	-78,6	-2,2				**82,62**	**2,26**
Colza	**estim.**	**2532,7**	**1,6**	**3076,1**	**23,4**	**3116,0**	**25,0**	**3230,7**	**29,6**	**3190,8**	**28,0**	**3138,5**	**25,9**	**3141,0**	**26,0**	**3,35**	**2576,43**	**2492,82**		
	deviat.	-43,7	-1,7	499,7	19,4	539,6	20,9	654,3	25,4	614,4	23,8	562,0	21,8	564,5	21,9				**532,23**	**20,66**
Sunflower	**estim.**	**2840,4**	**-2,3**	**2886,9**	**-0,7**	**2831,7**	**-2,6**	**2427,6**	**-16,5**	**2386,9**	**-17,9**	**2375,2**	**-18,3**	**2314,2**	**-20,4**	**-14,90**	**2474,00**	**2907,27**		
	deviat.	366,4	14,8	412,9	16,7	357,7	14,5	-46,4	-1,9	-87,1	-3,5	-98,8	-4,0	-159,8	-6,5				**261,24**	**10,56**

estim. = areas (x 1000 ha) and % change in relation to previous year estimated by Activity B
deviat. = difference between the Activity B estimate and the Eurostat official figures
% = change in area in relation to previous year
EUROSTAT final figures in May 1998 (x 1000 ha)

ANNEX 3

MARS ACTIVITY B ACREAGE ESTIMATES FOR THE MAIN CROPS AND DEVIATIONS IN RELATION TO EUROSTAT (1996): EUR-15

1996		APRIL		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		Eurostat	Eurostat (000 ha)		Aver. deviation	
		1000 ha	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	%	1996	1995	*1000 ha*	%
Cereals	**estim.**	**36606,8**	**2,9**	**37033,7**	**4,1**	**36998,1**	**4,0**	**36998,1**	**4,0**	**36962,5**	**3,9**	**37069,2**	**4,2**	**37069,2**	**4,2**	**3,83**	**36938,86**	**35575,08**		
	deviat.	-332,1	-0,9	94,8	0,3	59,2	0,2	59,2	0,2	23,7	0,1	130,4	0,4	130,4	0,4				**151,59**	**0,41**
Total wheat	**estim.**	**16950,9**	**2,4**	**17026,0**	**2,8**	**17471,0**	**5,5**	**17352,7**	**4,8**	**17354,7**	**4,8**	**17344,3**	**4,7**	**17330,9**	**4,7**	**2,44**	**16961,96**	**16558,59**		
	deviat.	-11,1	-0,1	64,0	0,4	509,1	3,0	390,7	2,3	392,7	2,3	382,4	2,3	368,9	2,2				**348,98**	**2,06**
Common wheat	**estim.**	**13747,7**	**2,5**	**14029,3**	**4,6**	**14404,9**	**7,4**	**14163,5**	**5,6**	**14150,0**	**5,5**	**14136,6**	**5,4**	**14123,2**	**5,3**	**2,61**	**13761,77**	**13412,36**		
	deviat.	-14,1	-0,1	267,6	1,9	643,1	4,7	401,7	2,9	388,3	2,8	374,9	2,7	361,4	2,6				**390,72**	**2,84**
Durum wheat	**estim.**	**3202,9**	**1,8**	**2992,1**	**-4,9**	**3061,3**	**-2,7**	**3187,1**	**1,3**	**3202,9**	**1,8**	**3206,0**	**1,9**	**3206,0**	**1,9**	**1,72**	**3200,49**	**3146,24**		
	deviat.	2,4	0,07	-208,4	-6,5	-139,2	-4,3	-13,4	-0,4	2,4	0,07	5,5	0,2	5,5	0,2				**94,92**	**2,97**
Barley	**estim.**	**11678,9**	**6,1**	**11502,8**	**4,5**	**11106,6**	**0,9**	**11282,7**	**2,5**	**11293,7**	**2,6**	**11304,7**	**2,7**	**11293,7**	**2,6**	**3,96**	**11442,99**	**11007,49**		
	deviat.	236,0	2,1	59,8	0,5	-336,4	-2,9	-160,3	-1,4	-149,3	-1,3	-138,3	-1,2	-149,3	-1,3				**193,41**	**1,69**
Maize	**estim.**	**3937,3**	**4,5**	**4016,4**	**6,6**	**3877,0**	**2,9**	**3813,0**	**1,2**	**3828,0**	**1,6**	**3843,1**	**2,0**	**3850,6**	**2,2**	**10,78**	**4173,80**	**3767,74**		
	deviat.	-236,5	-5,7	-157,4	-3,8	-296,8	-7,1	-360,9	-8,6	-345,8	-8,3	-330,7	-7,9	-323,2	-7,7				**300,57**	**7,20**
Colza	**estim.**	**2914,0**	**2,1**	**2814,1**	**-1,4**	**2822,6**	**-1,1**	**2865,4**	**0,4**	**2842,6**	**-0,4**	**2811,2**	**-1,5**	**2799,8**	**-1,9**	**-8,28**	**2617,83**	**2854,02**		
	deviat.	296,1	11,3	196,2	7,5	204,8	7,8	247,6	9,5	224,8	8,6	193,4	7,4	182,0	7,0				**223,77**	**8,55**
Sunflower	**estim.**	**2955,5**	**18,1**	**2214,8**	**-11,5**	**2447,5**	**-2,2**	**2445,0**	**-2,3**	**2430,0**	**-2,9**	**2425,0**	**-3,1**	**2425,0**	**-3,1**	**-2,32**	**2444,61**	**2502,55**		
	deviat.	510,9	20,9	-229,9	-9,4	2,9	0,1	0,4	0,0	-14,6	-0,6	-19,6	-0,8	-19,6	-0,8				**212,08**	**8,68**

estim. = areas (x 1000 ha) and % change in relation to previous year estimated by Activity B
deviat. = difference between the Activity B estimate and the Eurostat official figures
% = change in area in relation to previous year
EUROSTAT final figures in May 1998 (x 1000 ha)

ANNEX 4

MARS ACTIVITY B ACREAGE ESTIMATES FOR THE MAIN CROPS AND DEVIATIONS IN RELATION TO EUROSTAT (1997): EUR-15

1997		APRIL		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		Eurostat	Eurostat (000 ha)		Aver. deviation	
		1000 ha	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	*1000 ha*	%	%	1997	1996	*1000 ha*	%
Cereals	**estim**	**37736,7**	**2,2**	**38220,6**	**3,5**	**38209,6**	**3,4**	**38294,5**	**3,7**	**38298,2**	**3,7**	**38039,6**	**3,0**	**37991,6**	**2,9**	**3,07**	**38071,22**	**36938,86**		
	deviat.	-334,5	-0,9	149,4	0,4	138,3	0,4	223,3	0,6	227,0	0,6	-31,6	-0,1	-79,6	-0,2				**193,49**	**0,51**
Total wheat	**estim.**	**17446,6**	**2,9**	**17296,3**	**2,0**	**17334,6**	**2,2**	**17329,3**	**2,2**	**17320,3**	**2,1**	**17250,7**	**1,7**	**17231,3**	**1,6**	**1,65**	**17242,08**	**16961,96**		
	deviat.	204,5	1,2	54,2	0,3	92,6	0,5	87,2	0,5	78,2	0,5	8,6	0,0	-10,8	-0,1				**98,01**	**0,57**
Common wheat	**estim.**	**14215,9**	**3,3**	**14059,0**	**2,2**	**14101,7**	**2,5**	**14105,8**	**2,5**	**14076,9**	**2,3**	**13999,9**	**1,7**	**13995,7**	**1,7**	**1,88**	**14020,13**	**13761,77**		
	deviat.	195,8	1,4	38,9	0,3	81,6	0,6	85,7	0,6	56,8	0,4	-20,3	-0,1	-24,4	-0,2				**91,08**	**0,65**
Durum wheat	**estim.**	**3230,3**	**0,9**	**3237,3**	**1,2**	**3232,8**	**1,0**	**3223,2**	**0,7**	**3243,4**	**1,3**	**3251,1**	**1,6**	**3235,7**	**1,1**	**0,67**	**3221,95**	**3200,49**		
	deviat.	8,3	0,26	15,3	0,5	10,9	0,3	1,3	0,0	21,4	0,66	29,1	0,9	13,7	0,4				**16,56**	**0,51**
Barley	**estim.**	**11739,4**	**2,6**	**12237,1**	**6,9**	**12054,0**	**5,3**	**12119,3**	**5,9**	**12146,7**	**6,2**	**11959,1**	**4,5**	**11930,5**	**4,3**	**4,07**	**11908,40**	**11442,99**		
	deviat.	-169,0	-1,4	328,7	2,8	145,6	1,2	210,9	1,8	238,3	2,0	50,7	0,4	22,1	0,2				**193,52**	**1,63**
Maize	**estim.**	**4272,7**	**2,4**	**4233,9**	**1,4**	**4280,2**	**2,6**	**4337,8**	**3,9**	**4325,3**	**3,6**	**4316,1**	**3,4**	**4312,8**	**3,3**	**4,46**	**4359,90**	**4173,80**		
	deviat.	-87,2	-2,0	-126,0	-2,9	-79,7	-1,8	-22,1	-0,5	-34,6	-0,8	-43,8	-0,1	-47,1	-1,1				**71,36**	**1,64**
Colza	**estim.**	**2478,0**	**-5,3**	**2606,0**	**-0,5**	**2696,4**	**3,0**	**2696,1**	**3,0**	**2748,2**	**5,0**	**2751,9**	**5,1**	**2760,5**	**5,5**	**6,29**	**2782,37**	**2617,83**		
	deviat.	-304,3	-10,9	-176,3	-6,3	-86,0	-3,1	-86,3	-3,1	-34,2	-1,2	-30,5	-1,1	-21,9	-0,8				**141,99**	**5,10**
Sunflower	**estim.**	**2755,1**	**12,7**	**2592,8**	**6,1**	**2500,6**	**2,3**	**2447,1**	**0,1**	**2331,2**	**-4,6**	**2354,9**	**-3,7**	**2298,7**	**'6,0**	**-4,54**	**2333,74**	**2444,61**		
	deviat.	421,3	18,1	259,0	11,1	166,9	7,1	113,3	4,9	-2,6	-0,1	21,2	0,9	-35,1	-1,5				**202,48**	**8,68**

estim. = areas (x 1000 ha) and % change in relation to previous year estimated by Activity B
deviat. = difference between the Activity B estimate and the Eurostat official figures
% = change in area in relation to previous year
EUROSTAT final figures in May 1998 (x 1000 ha)

ANNEX 5

Operational activity contractors

Activity A

Contractor

Instituto de Estruturas agrárias e desenvolvimento rural (Portugal)
Ministerio de Agricultura, Pesca y Alimentación (Spain):

Activity B

Image analysis

Main contractor
SOTEMA Group

Subcontractor
SOTEMA
GEOSPACE
CISI AID
Bureau Veritas
Faculté de Gembloux

Image suppliers
SPOT IMAGE, S.A.
EIRIMAGE, SCRL.
G.A.F

Information technology and software
CISI INGENIERIE

Ground data:
Instituto de Estructuras Agrarias e Desenvolvimento Rural (IEADR)
Remote Sensing Data Engineering, Srl
Danish Institute of Plant and Soil Science
Katholieke Universiteit Leuven
Da Vinci Consulting
Österreichisches Statistisches Zentralamt
Desarrollo Agrario y Pesquero de Andalucía
Era-Maptec
Eftas Fernerkundung Technologietransfer, GmbH
Information Centre of Ministry of Agriculture and Forestry
Irco s.p.r.l
National Remote Sensing Center Limited
Trabajos Catastrales
Ministère de l'Agriculture et de la Pêche
Hunting Technical Services Ltd
Spazio Verde
Strabo, s.a.
Statistics Sweden

ANNEX 6

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ANNEX 7

Abbreviations used

CAMEL	Project Management Programme specially used by Activity B
EC	European Community
EEC	European Economic Community
CGMS	Crop Growth Monitoring System
ECU	European unit of account
ERS	Earth Remote Sensing
estim	Estimation
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
GRIPS	Geometric and Radiometric Image Processing System
IRS	Indian Remote Sensing Satellites
LANDSAT	System of Satellites for Earth Resources Observation
LISS	Multispectral Sensors on Board of IRS Satellites
MARS	Monitoring Agriculture by Remote Sensing
NDVI	Normalised Difference Vegetation Index
NOAA-AVHRR	Constellation of Satellites with Advanced Very High Resolution Radiometer
OCT.	October
OLIWIN	Agro-meteorological Model for the Estimation of Olive and Grapevine yields
ORCA	Orbital Remote Sensing of Crop Areas
CAP	Common Agricultural Policy
PC	Personal Computer
PHARE	Programme of economic restructuring aid for Central and East European countries.
SAR	Satellite
SEPT.	September
SPOT	Experimental Earth Observation system
TACIS	Technical Assistance to the Commonwealth of New Independent States
EU	European Union

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