The information model for crop protection in arable farming

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This report is a follow up of the PAGV report nr. 133: Information modelling for arable farming. Both reports are part of a European project 'cooperative development of decision support software using agricultural information models' within the EC CAMAR programme. Whereas in the previous report the general information model for arable farming has been described, this report focuses on certain business areas referring to crop protection more in detail.

The information model for 'crop protection in arable farming' is based on the farmer's decision-making process related to crop protection and therefore only information and decisions relevant to him are incorporated.

The information model is a reference model, because it is representative of every type of arable farm. Within the information model, the field of attention is limited by only considering measures aimed at the control of damage caused by diseases, pests and weeds. Damage caused by abiotic factors such as over-fertilisation, frost, hail or wind have not been incorporated in the model.

An information model is divided into two parts. The first part, which is the process model, describes the important functions of the farm and the processes belonging to these functions. When dividing it up into functions and processes, account was taken of the management cycle of the farm (planning, implementation and evaluation) and of the most important products and production resources.

The second part, the data model, describes the data used or created by these processes. The link between data- and process model is made with data flows.

The information model for 'crop protection in arable farming' can serve as starting point for the following activities at an international level:
- to standardize concepts, algorithms and decision rules concerning crop protection;
- to synchronize research activities for crop protection;
cooperative development of Decision Support Systems concerning crop protection.

Looking at the results of these projects, information modelling has proved to be a good tool for the development of consistent Decision Support Systems.
1. INTRODUCTION

There is a great deal of interest internationally in the approach and method chosen by the Netherlands in the field of Decision Support Development (DSS). In the late eighties the Dutch Ministry of agriculture has initiated some pilot activities to stimulate the use of Information Technology in agriculture. The financing of IT demonstration projects, the foundation of so called branch organizations on IT for farmers and the development of branch oriented and inter-branch oriented information models were the key activities of this Stimulation Programme for Information Technology.

In an information model the activities taken place on the farm are described as a hierarchy of functions and processes in the so called process model whereas the data related to these processes are structured and described in a data model. According to the Information Engineering method by James Martin Strategy a general arable farming information model has been developed. Later, several business areas of the general model have been detailed into elementary processes which has led to the so called detailed 'Arable farming information model' (IMOT; SIVAK, 1990). This information model is intended as a crop independent reference model for arable farming.

The information model can serve as a basic starting point within projects for the development of products such as:

- definitions/messages for the interchange of information between the farmer and organizations (e.g. accountants, consultants) and the annual adjustment of standard messages for financial and economic purposes;
- an interface for data interchange between Crop Management Systems and registration programs, and an interface between Crop Management Systems and board computers for tractors;
- an operational Farm Management System (BEA) at farm level which is used by advisors;
- several Decision Support Systems (DSS) as part of the integrated farm...
management system e.g. (Meijer & Kamp, 1991):
- the operational system (crop management system) for Sugar Beet (BETA) which is being commercialized by an organization newly set up in 1992;
- a operational system for the cereals Winter Wheat and Barley (CERA), which has been intensively tested by end-users (the farmers), CERA is also commercialized in 1992;
- a system for Cauliflower and Brussel Sprouts (KOBAS) which will be developed and tested in 1993;
- a prototype DSS for the control of potato root eelworm disease (TERRA).

On the basis of the results of these project, information modelling has proved to be a good tool for harmonizing concepts, algorithms and decision rules.

The information modelling approach has proven to be a successful methodology in the field of DSS developments. Existing international contacts led to the approval of an European project - 'cooperative development of decision support software using agricultural information models'. This project forms part of the EC CAMAR programme (Competitiveness of Agriculture and Management of Agricultural Resources).

The following organizations take part in the project:
- Department of Agriculture and Rural Development (DLG) in Germany, contact person K. Schlösser;
- Justus-Liebig-University of Giessen in Germany, contact person F. Kuhlmann;
- ACTA in France, contact person G. Waksman;
- INRA in France, contact person J. Attonaty;
- ITCF in France, contact person, G. Lemaitre;
- AGPM in France, contact person, D. Bloc;
- ADAS in the United Kingdom, contact person I. Houseman;
- Instituto Nacional de Investigaciones Agrarias in Spain, contact person J.L.G. Andujar;
Within the framework of this project, the Dutch 'General Arable Farming Information Model' has been translated into English to serve as a basis for the development of a European Information Model. The next step after the development of the Dutch 'General Information Model for Arable Farming' was to detail the defined business areas into elementary processes. This detailed 'Arable Farming' information model (IMOT; SIVAK, 1990) is intended as a crop-independent reference model.

The detailed information model for arable farming (IMOT) provides insight into the farmer's decision-making process. A general description is available in English and is entitled 'Information modelling for arable farming' PAGV report nr. 133 by A.J. Scheepens.

The standards set in IMOT can also be used to attune standards at an international level. Together with the other participants in the above-mentioned EC project, we have decided to give crop protection first priority for standardization. The first step is to make the information contained in IMOT accessible to the other participants. The results are presented in this report.

The area of crop protection is given first priority because new pest, disease and weed control management strategies will increase in importance as a result of the deteriorating income-expenditure ratio and the constant tightening of regulations concerning the use of chemicals in agriculture.

Within this context, an information model for arable farming can provide:

- better understanding of the interaction between different pest and disease control decisions;
- a starting point for the attunement at an international level of regulations, concepts and decision rules concerning crop protection measures;
- it can be used as a starting point for further international collaboration concerning the development of costly, knowledge-intensive systems.
This report can be seen as an extraction of the 'detailed information model for arable farming' (IMOT), concerning decision-making in the field of protecting crops against pests, diseases and weeds.

The basic starting points, the relationship with IMOT and conclusions which have been drawn from the information analysis, are described in text form and illustrated by means of simple diagrams in chapter 2. In order to make the model accessible to everyone, it has only been described in general terms.

The description of all business areas, processes and entity types incorporated in the model can be found in appendices C, D and E. Appendix A explains the Information Engineering methodology used in accordance with the Agricultural Information Modelling Approach (LIA); appendix B concerns the use of Information Engineering Workbench (IEW) in accordance with the LIA approach.

For the complete information model for crop protection, please refer to the model included in the Information Engineering Workbench (IEW), which is available at the Research Station for Arable Farming and Field Production of Vegetables (PAGV).
2. DESCRIPTION OF THE INFORMATION MODEL FOR CROP PROTECTION

2.1 Definition

According to Heitefuss (1989), crop protection may be defined as follows:
"Crop protection is the entire range of measures to prevent damage and yield reduction of useful plants by using all relevant scientific knowledge in an ecological and economically suitable way".

Within the information model, the field of attention is further limited by only considering measures aimed at the control of damage caused by diseases, pests and weeds. Damage caused by abiotic factors such as over-fertilisation, frost, hail or wind has not been incorporated in the model.

Critical success factors which have to be complied with in order to achieve this objective are:
- planning an effective strategy for operational protection measures is of vital importance;
- Choices have to be made within the plan such as:
  - whether the protection should be chemical or mechanical;
  - whether to take preventive or curative measures. Examples of preventive measures are: effective crop rotation systems and the choice of a variety resistant to the disease or pest;
- throughout all stages of the production process, strict control (by means of observation) of diseases, pests and weeds is of vital importance so as to ensure that effective measures can be taken in time;
- prediction of the population development for diseases or pests gives the farmer more support for his decision regarding whether or not to take timely protection measures;
- there are strict regulations for the use of chemical protection agents which
should be followed to the letter by the farmer. The farmer should therefore be fully up-to-date with current regulations;

- in addition, in order to be able to take the most effective and economically profitable decision, the farmer should be aware of the actual costs and benefits of a measure;

- any control of a disease or pest should be attuned to other cropping measures and should be carried out at the right moment. The crop protection plan, for example, should be attuned to the fertilisation plan.

On the basis of these critical success factors, the field of attention has been defined and a number of different sections or business areas have been incorporated in the crop protection model (see appendix C and figure 2). A short description of the used methodology can be found in appendix A. More information is included in the previous mentioned PAGV-report nr. 133.

Only the processes and data which support the decision-making process of a farmer in relation to crop protection have been incorporated. In addition, all information (including information formalized outside the farm) which is relevant to the implementation of these activities has been documented. Information has also been incorporated from external organizations playing a role in these activities.

In the 'detailed information model for arable farming', the area of crop protection has been divided between several different functions (see figure 1) and has not been identified as a separate information area or business area. In other words in IMOT, in accordance with the definition of a business area, crop protection is not described as a relatively independent and internally cohesive cluster of activities and information use. If we consider crop protection in this model as a separate cluster, a number of entity types, functions and processes will be grouped differently in relation to each other. An example is the function observation in IMOT. Observation is not a separate function in the information model for crop protection, but is subdivided into a number of processes which form part of the operational process Protect crops. The reason is
that observation is a critical success factor with regard to the choice of the best measure at the most suitable time and is consequently very closely related to the implementation of crop protection measures.

Figure 1. Functional decomposition diagram for 'arable farming'.
The processes below (1) are detailed in figure 3, the processes below (2) in figure 4 and the process below (3) detailed in figure 6.
2.1.1 The crop protection model’s link with IMOT

Crop protection can be seen as a section or business area of IMOT whereby the processes relating to crop protection and relevant data from IMOT are used as a basic starting point. The model for IMOT is described on the basis of the management cycle. Activities can be subdivided into three categories which together form a complete management cycle:

- planning;
- implementation;
- evaluation.

Within the crop protection processes, we can distinguish the same cycle. The crop protection processes can therefore be seen as processes of the following IMOT functions:

- Function 1. Strategic planning: the business policy for the coming years determines the content of the crop protection plan at a tactical and operational level. The chosen farming system (e.g. non-use of chemical agents, integrated farming system or conventional farming system) largely determines the preconditions for decisions at a tactical and operational level;

- Function 2. Tactical planning: at a tactical level, the production plan based on the farming system is crystallised further. The production plan is determined for the duration of one or more rotation cycles. The parasite and weed control plan also forms part of the production plan;

- Function 3. Operational planning and Function 5. Cropping: on operational level the variety choice and the process protect crops is further detailed within the crop protection model;

- Function 12. Evaluation: the process Evaluate crop protection evaluates the results in comparison with a weed and parasite protection plan or from specific crop protection measures.

2.1.2 Subdivision of the crop protection model into individual business areas

Just as crop protection can be distinguished from IMOT as a business area, we can also subdivide crop protection itself into different business areas. These individual
business areas are clearly defined sub-sections of the model which can be further analysed as separate clusters.

Using the affinity analysis from the Information Engineering Workbench (IEW), similar processes and entity types can be grouped on the basis of analogous associations. An analogous association exists, for example, if two processes make use of the same entity type. An example is the process **Match the description** which can create both an entity of the type **Actual description weed symptoms** and the type **Actual description parasite symptoms**.

This option is used within the crop protection model to distinguish clearly defined business areas which can be further analysed individually.

Making use of this option in IEW, the following business areas can be distinguished in crop protection (figure 2):

1. Formulation of a crop protection plan;
2. Determine the production possibilities;
3. Determine the actual environment;
4. Descriptions of symptoms;
5. Estimate damage parasite/weed;
6. Alternative tank mix;
7. Environmental impact of a protection operation;
8. Implement an operation;
9. Assessment of normative data;
10. Assign a crop to a certain field;
11. Stock control.
Figure 2. The decomposition of the business area crop protection into sub-sections or business areas which can be analysed separately. The CRUD matrix (figure 15) shows the interaction between those subject areas. The numbered subject areas are described in Appendix C.
The decomposition of the crop protection model into these business areas is illustrated by figure 2 and 16. Figure 2 shows the mutual relationship and difference in detailing between different business areas.

The business areas Assign a crop to a field and Stock control do not form part of the crop protection model, but are so relevant to the implementation of crop protection measures that they are described in connection with the crop protection model.

The descriptions of the different business areas and the processes and entity types per business area can be found in Appendix C.

In the following sections, the model is dealt with from the point of view of the processes. The data model has been created by means of analysis from the point of view of processes and data flows between the different processes. This approach clearly shows which data are important and which not when taking decisions.

2.2 The Process model

A number of main functions can be distinguished in IMOT, namely planning, operational activities and evaluation. The following processes are detailed further in the crop protection model:

- the process Formulate a management plan for cultivation included in function 2. Tactical planning (figure 3);
- the process Cultivate crop which forms part of function 5. Cropping has been detailed to include operational activities in the field of crop protection which form part of the process Protect crops (figure 4 and 5);
- function 12. Evaluation has been detailed with the process Evaluate crop protection activities (figure 6).

2.2.1 Formulate a management plan for cultivation

The process Formulate a management plan for cultivation comprises sub-processes which are of importance when planning crop protection activities (figure 3). Processes with a close relationship with crop protection and consequently
incorporated in the model are Divide the cultivation area and Determine the crop rotation plan. The two processes help to determine the content of the entity types weed and parasite control plan. These plans cover all other cropping cycles. Attunement of the choice of variety has been incorporated in this model as part of function 3. Operational planning.

In the process Formulate a parasite/weed control plan, a decision is taken to plan protection measures against a specific weed in a specific crop in order to prevent damage to a following crop.

2.2.2 Protect crops

The process protect crops forms part of function 5. Cropping from IMOT and covers all operational activities relating to crop protection on the arable farm.

The process is subdivided into the processes Plan crop protection measures (figure 4) and Implement crop protection operations (figure 5).

In the process Plan crop protection measures, the probability that a disease, pest or weed attacks the plant is first determined by means of the process Determine the probability of a parasite/weed. In order to be able to estimate this probability, the crop and weather conditions need to be determined. If these conditions are such that a parasite could be expected in the crop, an observation is planned. Figure 9 illustrates the different data flows between the different sub-processes of Determine the probability of a parasite or weed. The content of the different data flows can be referred to in appendix D (process model).

On the basis of the incoming flow planned observation, a decision is taken to make an observation whereby the observed symptoms are described and compared with normative symptoms of known diseases or pests for the crop concerned. The infestation pressure is also determined (figure 10).

On the basis of the infestation pressure and crop development, the epidemiological growth is estimated which can then be used to ascertain the expected damage to the product in a qualitative and quantitative sense. The data flow diagram of the process Prognosis of the potential damage illustrates the relationship between the data
required to calculate the expected damage (figure 11).

Within the process **Implement crop protection measures**, it is first necessary to decide on the best possible protection operation (sub-process: **Decide about crop protection**). This decision is made on the basis of the following information (figure 13):

- the flow estimated damage parasite/weed and identified parasite/weed as a result of the process **Plan crop protection measures**;
- the conditions such as the actual weather and crop condition;
- the availability of **equipment** and **crop protection agents** (stock);
- information needed to determine the cost and benefits such as: the expected yield, price of the crop and price of the crop protection agent;
- **protection threshold** determined by the process **Evaluation crop protection measures**;
- **environmental effects** of such an operation;
- restrictions in force regarding soil properties and water catchment area and restrictions resulting from the farming system.

On the basis of the crop, restrictions imposed by the farming system (e.g. non-use of chemical protection agents) and restrictions with respect to the soil and water catchment area, a choice of agents which can be used is then made from the table of crop protection agents (= process **Restrict number of protection agents**) (figures 5 and 13).

On the basis of the identified parasites and the permitted protection agents, combinations are then determined for a tank mix. In the case of each tank mix, a suitable operation is sought, depending on the available equipment.

By driving through the crop with the spraying equipment, it can cause damage to the crop. This damage is estimated in the process **Estimate damage protection operation** (figures 5 and 13).

Given the permitted and available **crop protection agents**, the damage caused by a parasite or weed, the damage to the crop caused by an operation and
environmental effects, it is then necessary to choose the most suitable protection operation (figure 14).

When choosing an economically optimum operation, two decision procedures can be used:

1. the use of a fixed protection threshold. Operations which exceed this threshold are cost-effective. As a starting point for this decision rule, use is made of the infestation pressure or the number of insects observed or number of leaves infected etc. (Process: Use the protection threshold). The fixed protection threshold is a normative factor which is established on the basis of the relationship between the number of weeds, diseases or pests and the expected financial damage. This relationship is based on an average of several years and regions. The consequence is that differences in the yield level, differences in price and the efficacy of crop protection agents are not considered. It is, however, possible to attune the crop protection threshold to measures to be carried out for other crops in the cropping plan;

2. the use of a cost/benefit analysis (Process: Analyse cost/benefits). The calculation of the costs is based on the following information:

   - the estimated drop in yield of the crop if no protection is carried out;
   - damage to the crop caused by implementation of a crop protection measure;
   - the price of the crop protection agents which form part of the tank mix;
   - if required the cost of labour (at contract work rate) and costs of mechanisation can be included in the calculation.

Where benefits are concerned, account is taken of the following:

   - a indicator number for the efficacy of a crop protection operation. When determining the efficacy of a operation, the efficacy of individual crop protection agents on the pests, diseases or weeds to be controlled is taken into consideration;
   - the estimate of the damage which may be caused by the combined disease(s), pest(s) or weed(s) which have been observed. The expected damage is related to the expected yield;
- the physical damage is converted into a figure for financial damage on the basis of the product price per kg.

By using information more specifically related to the plot in question, this last decision procedure will result in advice which is better suited to the situation. One disadvantage, however, is that much more information is necessary before the advice stage can be reached. In particular, calculation of the infestation pressure and an estimate of the damage caused require a great deal of research.

Within the decision procedure a choice is made between the type of operation. Operation types are for example: spraying the whole field, spraying only rows or hoeing.

In addition to a financial evaluation of crop protection agents, damage to the environment is also taken into consideration when choosing an operation. Likewise the availability of an agent.

A date and the equipment needed for the protection operation are then determined. Once the need for crop protection has been established, it is usual for the tank mix and necessary equipment to be prepared for implementation of the protection operation.

When a protection operation has been carried out, a new observation can be considered depending on the normative data concerning the duration of effectiveness of the agents used in the tank mix. The cycle within the process protect crops can then be restarted.

2.2.3 Evaluate crop protection activities

The process Evaluate crop protection activities forms part of function 12. Evaluation (figures 1 and 6). An important sub-process is to determine the normative data which are important as input for the process protect crops. The normative data are based on average values established by research based on different farm situations and a number of years. With the observed results of implemented operations and observation of the surrounding conditions in the process Protect crops, the normative data specific to the farm can be adjusted (figure 15).
Depending on the parasite and weed control plan drawn up by the process Formulate the crop protection program (figure 3) and the farming system, the observation and operation criteria can be established (Process: Determine the observation criteria and Determine the operation criteria).
In addition, conditions around the farm are determined which might be of importance to internal decisions concerning crop protection (Process: Observe circumstances around the farm).

2.3 The data model

In the data model (figure 17) there is a description of information which the farmer wishes to retain for crop protection. Part of this information comes from external agents, e.g. Plant Protection Service, extension service or research. This information is classified in the model as external normative data.
In addition we have normative data, specifically applicable to the farm in question, which is produced by the farmer's own evaluation process (Process: determine the normative data).

On the basis of the business areas, the data model is subdivided into different subject areas (see appendix C).
There is also current information available which is created or changed within the farm (see CRUD matrix; figure 15).
Figure 3. Process decomposition of **Formulate management plan for cultivation**. This figure is an extension of figure 1: part (1).
Figure 4. Process decomposition of Protect Crops and Plan crop protection measures. This figure is an extension of figure 1: part (2).
Figure 5. Process decomposition of implement crop protection measures. This figure is an extension of figure 4: part (4).
Figure 6. Process decomposition of Evaluate crop protection. This figure is an extension of figure 1: part (3).
Figure 7. Data Flow diagram: Protect Crops with the sub-processes Plan crop protection measures and implement crop protection measures.
Figure 8. Data Flow diagram: Plan crop protection measures with the sub processes
Determine probability of infestation, Make an observation and Prognosis of the
potential damage.
Figure 9. Data Flow diagram: Determine probability of infestation with the sub-processes Determining the crop conditions, Analyze the weather conditions, Compare the actual conditions with historical conditions and Plan an observation.
Figure 10. Data Flow diagram: Make an observation with the sub-processes Identify parasite or weed and Infestation prognosis.
Figure 11. Data Flow diagram: Prognosis of the potential damage with the sub-processes Estimate the epidemical growth and Estimate damage parasite/weed.
Figure 12. Data Flow diagram: Implement crop protection measures with the sub-processes Decide about crop protection, Plan protection operation and Prepare the protection operation and Carry out the operation
Figure 13. Data Flow diagram: **Decide on crop protection** with the sub-processes **Restrict the number of Protection agents**, **Propose a tank mix**, **Determine the suitable protection agents**, **Estimate the damage protection operation** and **Choose a protection operation**.
Data flow diagram: Choose a protection operation with the sub-processes Choose a method for comparison, Compare environmental effects, Examine the availability.
Figure 15. Data flow diagram: Determine the normative data with the sub-processes Assess the normative weather conditions, Assess the normative occurrence parasite/weed, Assess the normative crop status, Assess the protection threshold, Assess the expected yield, Assess the environmental effects and Assess the normative field conditions.
### Figure 16: Crud matrix: interaction between data and process model

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**Legend:**
- '+' represents a positive interaction.
- '-' represents a negative interaction.
- '0' represents no interaction.

*Note: The matrix is a simplified representation and may not capture all interactions.*
Figure 17A. The entity relationship diagram for the subject areas: 10. Assign a crop to a field, 1. Formulate crop. prot. plan and 2. Determine the variety.
Figure 17B. The entity relationship diagram for the subject areas: 3. Determine the actual environment, 4. Description of symptoms, 5. Estimate damage parasite/weed, and 6. Alternatives tank mix.
Figure 17C. The entity relationship diagram for the subject areas: 7. Environmental effects prot. op, 8. Implement a prot. operation, 9. Determine normative data, 10. Assign a crop to a field and 11. Stock control
REFERENCES

   Crop and plant protection; the practical foundations 261p

   Development and introduction of crop management systems. In: Proceedings
   of a workshop on Computer-based Plant Protection Advisory Systems,
   Copenhagen 27-29th November 1991

   Information modelling for arable farming, PAGV report nr. 133

SIVAK, 1990.
   The detailed information model for arable farming; IMOT (in dutch)
Appendix A  Methodology and technique

A1  Introduction

A good information system is characterized by interrelated subsystems. On the basis of this, programs can be developed in which the subprograms are coordinated with each other and the data interchangeable. Furthermore, new functional specifications must be easy to integrate into the system. A good information system should provide an up-to-date picture of the part of the current situation relevant to the business or organization. It is therefore very important to have a structured approach and method.

The method which is used for the development of information systems in arable farming and market gardening is based on Information Engineering. Information Engineering is supported by James Martin Strategies and represents a cohesive aggregate of methods, techniques and tools which can be used to create information systems for a business or organization. The separate parts of the method are constantly attuned to the information needs and priorities of the business or organization.

An important basic principle of this method is that the development should take place in accordance with a 'top-down' approach. This means that products to be supplied become on the one hand increasingly detailed and on the other hand cover an increasingly narrow area.

The method used is briefly described below using examples from the detailed model of the cluster 'Crop Protection'.
A2 Method

In the information model, the activities and decisions which take place on an arable farm are illustrated by means of charts. All data playing a role in these activities are also incorporated. The activities are to be found in the process model; the data relating to these activities and which have to be saved are described in the data model.

The relationship between the different functions, processes and external organizations is graphically illustrated in a data flow diagram.

Appendix F includes a summary of the concepts and symbols used.

A2.1 The process model

All the activities of a farm are described in a process model. The relationship between the processes is shown by means of information flows, both within the farm and with external organizations.

Functions and processes

In the information model, functions and processes are separated. A function is a main activity of a business, with a more or less continuous nature.

A process is a part of a function, the implementation of which is demonstrable and which has a clear starting point and end. When making the detailed information model, processes are further elaborated into elementary processes. A process is usually indicated by a verb. An elementary process is the smallest possible activity which is carried out as a whole and which is relevant to the management of the farm from the point of view of the supply of information. This means that new information is generated by an elementary process, or existing information is changed.

Within the function Management auxiliary materials there is for example a separation between the processes Purchase of auxiliary material and Stock control of auxiliary material. Grouping the activities within the farm consecutively
in functions and processes gives rise to the process decomposition diagram (see figures 1, 3 and 4).

A process requires a **process description**. This states what the process consists of, what information is necessary for the process to run smoothly and what information is subsequently made available as a result of the process. Information necessary for carrying out a process are indicated within destination flows. Information supplied by a process are indicated with source flows. A link is made here between process and data models because the information flows between processes consist of entity types and attributes. Figure 18 shows the detailing of the process description for the process **Describe the symptoms**.

<table>
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<th>Process: Describe the symptoms</th>
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<tr>
<td><strong>Definition</strong></td>
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<tr>
<td>Describe the characteristics of a spot, weed or insect detected in the cultivated crop.</td>
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</table>

| **Entity type**: Actual description weed symptoms |
| **Attributes**: Name |
| Description of symptom |

| **Entity type**: Actual description parasite symp. |
| **Attributes**: Name |
| Description of symptom |

**Destination of:**
- **Data Flow**: planned observation
  - **Entity type**: Observation
  - **Attributes**: Status (plan., imp., carr.out), planned date

**Destination of:**
- **Data Flow**: crop destination
  - **Entity type**: Crop rotation plan
  - **Entity type**: Crop
  - **Entity type**: Field
  - **Relations**: Field is designated to Crop rotation plan
  - **Field belongs to Crop rotation plan**

Figure 18. Example of a Process description: **Describe the symptoms**, a process of the Function 5. Cropping

**A2.2 The data model**

A data model describes the activities in a company concerning which information has to be recorded. This information is generated by the processes of the process model or comes from an external agent. A data model concerns information (entity types and attributes) which are kept for a longer or shorter period of time. It may on the
one hand concern basic information (including actual weather and crop information) which either originates from outside the farm or is 'measured' on the farm. On the other hand, it may concern information which is generated by a process and is then required for the implementation of other processes.

The purpose of making a data model is to define and classify data and indicate their inter-relationships.

The following concepts play a role here: entity type, entities, attributes and relationships.

**Entity types**

An entity type is a group of objects (entities) relevant to a business and concerning which information is needed. These entities may concern physical objects (machine) or events (supply) or theoretical concepts (growth stage). An entity type is described by data which provide usable information concerning that object. These data are called attributes. Entity types are defined from the point of view of information systems. An entity is an occurrence of an entity type. For example: an entity of the entity type operation is spraying a crop protection agent using the row sprayer.
**Entity type: Field**

**Definition:** A continuous piece of land, considered to be homogeneous by the farmer with regard to soil type, production capacity, crop rotation plan, history and other requirements of the farmer. Different crops are usually grown consecutively in a field.

**Relationship:**
- is part of: Plot
- is destined to: Crop rotation plan
- is described by: Soil type
- knows: Actual soil condition
- knows: Planned soil condition
- restricts: Crop protection agent

**Attributes:**
- Field code
- Description
- location of field
- shape of field
- length
- Width
- Water catchment area (Y/N)
- location
- area

Figure 19. Example of a Entity type description

The general 'arable farming' information model includes the entity type Field (see figure 19). This entity type concerns all possible fields which fall under this common description. An entity of the entity type field is for example a field referred to as 'the back field'. This entity has for example code 21 and as a further description: 'the back field'.

It is possible for an entity type to be subdivided into not only common characteristics of the entity main type but also extra information characteristics. The entity main type
operation can be subdivided into the entity subtypes observation.

Attributes
Attributes are the properties of an entity type. One of these unique properties (or a combination (concatenation) of several) forms a unique identification of an entity type. This is also known as the key and is indicated in the data model by id. For example: (the entity type field is uniquely identified by the attribute field code.)

Relationships
A relationship shows a link between entity types and is of importance from the point of view of the supply of information. All entity types and the relevant relationships are illustrated in the entity relationship diagram.

There are different types of relationships:

a) Cardinality;

The chart below shows on the one hand that one tractor, once bought, requires a quantity of petrol one or more times. This is indicated by a 'crow's-foot' alongside an entity type which occurs more than once. On the other hand, a quantity of petrol always goes to one tractor; this is indicated by the small lines at right angles to the relationship.

Cardinality shows whether an entity of entity type A has a link with one or more entities of entity type B within one specific relationship. There are three possible cardinalities:
b) **Exclusivity;**

If two (or more) relationships are exclusive, this means that an entity of the entity type can only occur in one of the relationships at the same time.

The above chart shows that maintenance is carried out on a building or equipment. Maintenance cannot contain machine and building data simultaneously. A relationship of this nature is indicated in the model by putting the abbreviation 'ex' in front of the name of the relationship.

c) **Optionality;**

The optionality of a relationship indicates that a relationship can occur, but does not necessarily have to be present.
The above chart shows on the one hand that a piece of equipment, once bought, is repaired zero, one or more times. In reverse, a repair in this chart always relates to one piece of equipment. This is graphically illustrated by a 'O' on the side of the entity type which may or may not occur (is optional).

It is also possible for both entity types to participate optionally in the relationship. This is indicated by placing an 'O' on both sides in the relationship.

**Keys**

Keys provide unique identification of one entity of an entity type. An entity type has one or more keys. For example: in a warehouse all articles will be furnished with an article code with a number of characteristics of the relevant article. The article code forms the key. In this way, one entity distinguishes itself another entity. The value of the keys for each entity should always be known. In the information model keys are indicated with the aid of key attributes.

**Interpretation of the data model chart**

In an entity relationship diagram relationships can be read in two directions. For this reason, for the sake of clarity words have been placed by the relationships. These should be read clockwise together with the names of the entity types.

The relationship 'service is carried out for equipment' indicates that a service concerns a equipment. Conversely equipment can have a relation with service (the relationship 'equipment undergoes a service').
A3 Interaction between process and data models

The process and data models must be fully attuned to each other. Entity types should be used with each defined process. These data may be generated by other processes. The data may also be supplied by external information sources. Within the model each defined process must create at least one entity type and use at least one entity type. If this is not the case, the model would be incorrect or incomplete. Information would then be created which is apparently not used in decisions or information is required which is never created. The relationship between processes and data is illustrated in a matrix showing which entity types are created or used per process, the so-called CRUD matrix (see figure 16).

The information flows for the underlying processes are given per function in data flow diagrams. The connecting lines between the processes show the input or output of a process and concern information. The double lined boxes indicate external agents which either provide or use information. "This model does not describe how these organizations produce information or what they do with it."

Interpretation of the data model chart

A dataflow diagram displays the processes, data stores, external agents, junctions and dataflows of one level of decomposition of a process. The process described by a data flow diagram is the topic of the diagram. The processes displayed in the diagram are the children of the topic process (see figure 6).

An external agent is an object which receives or sends data but does not form part of the specific business area model. External agents for the crop protection model are, for example, suppliers of crop protection agents or other relevant sources of information such as the information service.
A4 The phasing used and the products which should be produced per phase

In the method used by the agricultural sector in The Netherlands, the development stage of information systems is divided into the following phases:

1. formulation of a general information model;
2. formulation of a detailed information model;
3. formulation of system specifications;
4. determination of research requirements;
5. formulation of a technical design;
6. construction of the system;
7. implementation and maintenance;

ad 1) formulation of a general information model

The following 'products' are relevant:

- function and functional decomposition of the farm;
- data model of the company (entity types and relationships);
- matrix of processes versus entity types and business areas of processes and data.

The level of detail of the general information model is such that decisions can be taken about definition in information areas and about priorities for further analysis and development.

ad 2) formulation of a detailed information model

The general model is given more detail. In order to do this, the general model is split up into clusters: relatively homogeneous sections within which many relationships exist and with few relationships with other sections. This detailing provides better insight into the information which is important for company decisions.

The following products are generated during this phase:

- functional decomposition to elementary processes;
- detailed data model (entity types, relationships and attributes and their
ad 3) formulation of system specifications

The following products are relevant for this phase:

- logical database design;
- description of procedures of the information system;
- layout of screens, sequence of screens;
- layout of reports;
- data flow diagrams;
- access diagrams.

ad 4) Phase 4 shows in which sections of a company there is still insufficient knowledge available to be able to develop information models and systems.

ad 5) In phase 5 the technical design of the system is formulated.
Appendix B  The use of the Information Engineering Workbench

Use has been made of the Information Engineering Workbench (IEW) for the development of the model for Crop protection.
Reasons which justify the use of a case tool are:

- improvement of the quality of the system which has been developed due to the fact that all kinds of consistency controls are supported by the workbench;
- the use of the reference 'the detailed information model for arable farming' (IMOT) and the re-use of parts of related models is simplified;
- an increase in productivity due to the back-up provided with diagrams and automatic production of reports.

The Information Engineering Workbench is built up of modules. Each module supports a development stage within the IE methodology.

For the development of the crop protection information model, use has been made of the Planning Workstation with which a process composition, a data model and subdivision of the model into business areas can be achieved. The relationships between entity types and processes can be illustrated in a CRUD matrix (figure 16).

On the basis of these association matrices it is possible, with the help of the affinity analysis option in IEW, to divide the model into related sections, the so-called business areas.

With the aid of the second module (Analysis Workstation), the identified business areas are analysed with the help of process decomposition, the entity type relation diagram and data flow diagrams. The data flow diagrams are a good way of safeguarding the consistency of the model. When a process within a data flow diagram is detailed in a data flow diagram at a lower level, IEW checks whether the source and destination flows of a process go to an external agent or another process.

In addition to the Planning and Analysis Workstation which supports the information analysis, IEW comprises the Design and Construction Workstations which support
technical implementation and the construction of the system respectively. Within the Design and Construction Workstations, the information model can be converted into a physical design.
Appendix C Description of business areas

Business area: 1. Formulate crop prot. plan

Definition: Formulate a parasite and weed control plan taking into account several cultivation years.

![Crud matrix for the subject area: 1. Formulate crop prot. plan]

Business area: 2. Determine the variety

Definition: Determine which variety will be cropped, taking into account the expected parasites and the applied farming system.

![Crud matrix for the subject area: 2. Determine the variety]

Business area: 3. Determine the actual environm.

Definition: Determine the environmental conditions important for crop, parasite and weed development.
Observation
Probability of parasite/weed
Actual weather conditions
Actual soil condition
Actual crop status

<table>
<thead>
<tr>
<th>Analyse the weather conditions</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine probability of infest.</td>
<td>C</td>
</tr>
<tr>
<td>Determine the crop conditions</td>
<td>C</td>
</tr>
<tr>
<td>Compare actual cond. with hist.</td>
<td>R</td>
</tr>
<tr>
<td>Plan an observation on weeds/par</td>
<td>R</td>
</tr>
</tbody>
</table>

Figure 22: Crud matrix for the subject area: 3. Determine the actual environment.

Business area: 4. Description of symptoms

Definition: Description of symptoms caused by parasites or weeds. These symptoms are obtained by an observation.

<table>
<thead>
<tr>
<th>Actual description weed symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual description parasite symp.</td>
</tr>
</tbody>
</table>

| Describe the symptoms | C | C |

Figure 23: Crud matrix for the subject area: 4. Description of symptoms

Business area: 5. Estimate damage parasite/weed

Definition: Estimate the damage caused by an identified parasite or weed.
1. Population dynamic parameters

- Soil type
- Weed symptoms
- Parasite symptoms
- Weeds
- Parasites

| Identify parasite or weed | R | R | C | C |
| Match the description | R | R | C | U |
| Infestation prognosis | R | R | C | C |
| Estimate the epid. growth | R | R | C | C | R | R | U |
| Prognosis potential damage | R | R |
| Estimate dam. parasite/weed | U | U |

Figure 24: Crud matrix for the subject area: 5. Estimate damage parasite/weed

**Business area: 6. Alternatives tank mix**

**Definition:** Propose different alternatives for a tank mix taking into account restrictions for e.g.:
- soil condition
- water catchment area:
- efficacy of operations including the efficacy of tank mixes

| Propose a tank mix | R | R | C | R | R |
| Restrict number of prot. agents | C | U | U |

Figure 25: Crud matrix for the subject area: 6. Alternatives tank mix

**Business area: 7. Environmental effects prot.op.**

**Definition:** The environmental effects as result of carrying out a protection operation.
Business area: 8. Implement a prot. operation

Definition: Decide which, prepare and carry out a protection operation.

Business area: 9. Determine normative data

Definition: Determine the farm properties taking into account average date over
several years, regions and farms.

**Figure 28: Crud matrix for the subject area: 9. Determine normative data**

**Business area: 10. Assign a crop to a field**

**Definition:** Divide the farm into one or more plots and fields, and destine a crop to a certain field.

---

**Figure 29: Crud matrix for the subject area: 10. Assign a crop to a field**
Business area: 11. Stock control

Definition: The purchase and stock control of auxiliary materials.

<table>
<thead>
<tr>
<th>Stock control of crop prot. ag.</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase of auxiliary materials</td>
<td></td>
</tr>
<tr>
<td>Purchase of crop protection ag.</td>
<td>R C</td>
</tr>
</tbody>
</table>

Figure 30: Crud matrix for the subject area: 11. Stock control
Appendix D  Description of the process model

Process: Analyse cost/benefits

Definition: Calculate for each crop protection operation how much of the total loss can be prevented and the total costs related to the operation.

Is source of:
- Data Flow: most efficient operation

Entity type: Operation
Attributes:
- name
- status (planned, prep, carr. out)
- expected total costs
- expected total benefits

Is Destination of:
- Data Flow: estimated damage parasite/weed

Entity type: Product
Attributes:
- description of product
- status (planned, harvested, store)
- yield capacity
- Expected yield loss

- Data Flow: estimated damage operation
- Data Flow: Actual weather conditions

Entity type: Actual weather conditions
Attributes:
- date of measurement
- time of measurement
- temperature
- vaporization
- relative humidity
- global radiation
- dew point
- figure for rainfall
- Period of registration

- Data Flow: efficacy tank mix

Entity type: Crop protection agent
Attributes:
- Name of crop protection agent
- efficacy
- Content of chemical act. agent

Relations: Crop protection agent contains Content of chemical act. agent

- Data Flow: efficacy of an operation
- Data Flow: alternatives for a tank mix

Entity type: Tank mix
Attributes:
- Name of tank mix
- Status (prop., prep., sprayed)

- Data Flow: Crop conditions
**Process:** Analyse the weather conditions

**Definition:** Determine the weather conditions at the actual moment.

**Process:** Assess environmental effects op.

**Definition:** Assess the environmental effects of an operation.
Process: Assess norm. weather cond.

Definition
Assess the normative weather conditions which can be expected during a specific season.

Is source of:
- Data Flow: Normative weather cond.

Process: Assess the efficacy of operation

Definition
Assess the efficacy of an operation concerning the control of a pest or disease.

Is source of:
- Data Flow: efficacy of an operation
  Entity type: Operation
  Attributes:
  name
  status (planned, prep, carr. out)

Is Destination of:
- Data Flow: actual soil condition
  Entity type: Actual soil condition
- Data Flow: Actual weather conditions
  Entity type: Actual weather conditions
  Attributes:
  date of measurement
  time of measurement
  temperature
  vaporization
  relative humidity
  global radiation
  dew point
  figure for rainfall
  Period of registration
- Data Flow: Crop conditions
  Entity type: Actual Crop status
  Attributes:
  development stage
- Data Flow: Crop
  Entity type: Crop
  Attributes:
  Crop code
Process: Assess the expected yield

Definition: Assess the expected yield and price taking into account the yield of previous years.

Is source of:
- Data Flow: Expected yield/price
Entity type: Product
Attributes:
- Status (planned, harvested, store)
- Expected price
- Yield capacity

Is Destination of:
- Data Flow: expected price product
Entity type: Product
Attributes:
- Description of product
- Expected price
- Data Flow: Normative weather cond.

Process: Assess the norm. crop status

Definition
Assess the crop status which can be expected at a certain moment taking into account the development of the crop previous years.

Is source of:
- Data Flow: Normative crop status
Entity type: Normative crop status
Attributes:
- Expected field emergence
- Expected field damage
- Development stage
- Data Flow: Normative crop status
  Entity type: Normative crop status
  Attributes:
  - Expected field emergence
  - Expected field damage
  - Development stage

**Process:** Assess the norm. occ. par./weed

*Definition* Assess the chance of occurrence of a parasite or weed under normative conditions.

**Is source of:**
  - Data Flow: norm. occurrence par./weed

**Entity type:** Norm. occurrence of a parasite/weed

**Attributes:**
  - expected occurrence

**Is Destination of:**
  - Data Flow: Normative crop status

**Entity type:** Normative crop status

**Attributes:**
  - Expected field emergence
  - Expected field damage
  - Development stage
  - Data Flow: Normative weather cond.

**Process:** Assess the normative field cond.

*Definition* Assess the field conditions specific to the farm.

**Is source of:**
  - Data Flow: normative soil condition

**Process:** Assess the protection threshold

*Definition* If the normative threshold is exceeded an operation for crop protection should be carried out taking into account costs and benefits.

**Is source of:**
  - Data Flow: protection threshold

**Entity type:** Protection threshold

**Attributes:**
  - limit weed density
  - unit

**Is Destination of:**
  - Data Flow: expected price product

**Entity type:** Product

**Attributes:**
  - description of product
  - expected price
  - Data Flow: total costs tank mix

60
Process: Carry out a protection operation

Definition: Carry out a protection operation according to the proposed procedure.
**active ingredient**

Name of tank mix:
Status (prop., prep., sprayed)

**Entity type:** Crop protection agent

**Attributes:**
Name of crop protection agent
average price (guild./kg)
Agent * mixture
Content of chemical act. agent

**Relations:**
Tank mix is used by Operation
Agent * mixture defines Tank mix
Crop protection agent is part of Agent * mixture
Crop protection agent contains Content of chemical act. agent

**Process:** Choose a method for comparison

**Definition:** Choose a method to compare different protection operations with respect to their efficiency, using either a protection threshold or a cost/benefit analysis.

<table>
<thead>
<tr>
<th>Is source of:</th>
<th>Is Destination of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Data Flow: most efficient operation</td>
<td>- Data Flow: estimated damage operation</td>
</tr>
</tbody>
</table>

**Entity type:** Operation

**Attributes:**
name
status (planned, prep, carr. out)
expected total costs
expected total benefits

<table>
<thead>
<tr>
<th>Entity type:</th>
<th>Product</th>
</tr>
</thead>
</table>

**Attributes:**
description of product
status (planned, harvested, store)
Yield capacity
Expected yield loss

<table>
<thead>
<tr>
<th>Entity type:</th>
<th>Weed * Symptoms</th>
</tr>
</thead>
</table>

**Attributes:**
Figure for infestation pressure
Status (expect, estimate, count.)

<table>
<thead>
<tr>
<th>Entity type:</th>
<th>Parasite * symptoms</th>
</tr>
</thead>
</table>

**Attributes:**
Figure for infestation pressure
Status (expect, detect, count.)

<table>
<thead>
<tr>
<th>Entity type:</th>
<th>Protection threshold</th>
</tr>
</thead>
</table>

**Attributes:**
limit weed density
unit

<table>
<thead>
<tr>
<th>Entity type:</th>
<th>Expected yield/price</th>
</tr>
</thead>
</table>

- Data Flow: infestation pressure
- Data Flow: protection threshold
- Data Flow: protection threshold
**Process:** Choose a prot. operation

**Definition:** Choose the optimal protection operation from all suitable protection operations. Important considerations are:
- the loss of yield which could be prevented by the application of a crop protection operation;
- the costs of the application. (e.g. cost of pesticides, wheelings, labour and machine costs).

**Process:** Compare actual cond. with hist.

**Definition:** Compare the crop conditions (e.g. stage) and the weather conditions with historical weather and cropping data in context with associated date of the appearance of certain parasites or weeds.
Process: **Compare costs/benefits**

**Definition:** Compare the costs and benefits for each operation

**Is source of:**
- Data Flow: most efficient operation

**Entity type:** Operation

**Attributes:**
- name
- status (planned, prep, carry out)
- expected total costs
- expected total benefits

**Is Destination of:**
- Data Flow: figure for total costs

**Entity type:** Operation

**Attributes:**
- name
- expected total costs

**Is Destination of:**
- Data Flow: total benefits of an operation

**Entity type:** Product

**Attributes:**
- description of product
- status (planned, harvested, store)
- expected price
- preventable yield loss
- Data Flow: Expected yield/price

**Entity type:** Product

**Attributes:**
- status (planned, harvested, store)
- expected price
- Yield capacity

Process: **Compare environment, effects**

**Definition:** Take into account the environmental effects of different operations for choosing the most optimal operation.

**Is source of:**
- Data Flow: selected operation

**Entity type:** Operation

**Attributes:**
- name
- status (planned, prep, carry out)

**Is Destination of:**
- Data Flow: most efficient operation

**Entity type:** Operation

**Attributes:**
- name
- status (planned, prep, carry out)
- expected total costs
Process: Compare results - expectations

Definition: Compare the actual results of plant protection measures with their expected results based on normative data. If there is inconsistency the normative data should be adjusted.

Process: Crop destination

Definition: Assign a crop to a certain field.

Process: Cultivate crop

Definition: All operational cultivation operations.
- Data Flow: identified parasite/weed

Entity type: Weed
Attributes:
- Status (expect, estimat., count.)

Entity type: Parasite
Attributes:
- Status (expect, detect., count.)

Entity type: Weed
Attributes:
- Name
- Development stage

Entity type: Parasite
Attributes:
- Name
- Development stage

Relations:
- Weed is compared to Weed * Symptoms
- Parasite is compared to Parasite * symptoms

- Data Flow: infestation prognosis
- Data Flow: estimated damage parasite/weed

Entity type: Product
Attributes:
- Description of product
- Status (planned, harvested, store)
- Yield capacity
- Expected yield loss

- Data Flow: soil & field restrictions

Entity type: Field
Attributes:
- Field code
- Description
- Water catchment area (Y/N)

Entity type: Soil type
Attributes:
- Organic matter content
- Classification, size of soil particles

Relations:
- Field is described by Soil type

- Data Flow: stock

Entity type: Stock
Attributes:
- Time of inspection of stock
- Quantity in stock

Entity type: Crop protection agent
Attributes:
- Name of crop protection agent
- Content of chemical act. agent

Relations:
- Crop protection agent is available Stock
- Crop protection agent contains Content of chemical act. agent

- Data Flow: Crop conditions
**Entity type:** Actual Crop status

**Attributes:**
- development stage

**Entity type:** Crop

**Attributes:**
- Crop code
- Name

**Relations:** Actual Crop status describes the status of a Crop

- Data Flow: equipment

**Entity type:** Set of equipment

**Entity type:** Tangible fixed asset

**Attributes:**
- code
- type code
- width of tyres
- width of spraying arm

**Relations:** Tangible fixed asset is put on Set of equipment

- Data Flow: environmental effects op.

**Entity type:** Environmental effects assessment

**Attributes:**
- Risk for persistence
- Risk for eluviation
- Toxicity to warm-blooded org.
- Toxicity to non-target org.

**Entity type:** Operation

**Attributes:**
- name
- type of operation

**Relations:** Environmental effects assessment is caused by Operation

- Data Flow: Actual weather conditions

**Entity type:** Actual weather conditions

**Attributes:**
- date of measurement
- time of measurement
- temperature
- vaporization
- relative humidity
- global radiation
- dew point
- figure for rainfull
- Period of registration

- Data Flow: actual soil conditions

**Entity type:** Soil type

**Entity type:** Field

**Attributes:**
- Field code
**Process:** Describe the symptoms

**Definition:** Describe the characteristics of the host plant, weed or insect detected in the cultivated crop.

**Process:** Det. allowed prot. agents

**Definition:** Determine which crop protection agents are allowed and can be applied under the given circumstances.

**Process:** Determine the normative data

**Definition** Determine all feasible (normative) conditions (e.g. development stage crop, development stage disease/pest, diseases which are able to attack the crop) which can appear on the farm.
**Process:** Determine operation crit.

**Definition:** Determine all criteria which are relevant for the implementation of an operation. The criteria are also based on historical data.

**Process:** Determine probability of infest.

**Definition:** Determine the probability of infestation for a certain parasite or weed. Based on the outcome of this process the farmer will plan actual observations of specific parasites or weeds.

<table>
<thead>
<tr>
<th>Is source of:</th>
<th>Is Destination of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Data Flow: Actual weather conditions</td>
<td>- Data Flow: Normative crop status</td>
</tr>
<tr>
<td><strong>Entity type:</strong> Actual weather conditions</td>
<td><strong>Entity type:</strong> Normative crop status</td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td><strong>Attributes:</strong></td>
</tr>
<tr>
<td>data of measurement</td>
<td>Expected field emergence</td>
</tr>
<tr>
<td>time of measurement</td>
<td>Expected field damage</td>
</tr>
<tr>
<td>temperature</td>
<td>Development stage</td>
</tr>
<tr>
<td>vaporization</td>
<td></td>
</tr>
<tr>
<td>relative humidity</td>
<td></td>
</tr>
<tr>
<td>global radiation</td>
<td></td>
</tr>
<tr>
<td>dew point</td>
<td></td>
</tr>
<tr>
<td>figure for rainfall</td>
<td></td>
</tr>
<tr>
<td>Period of registration</td>
<td></td>
</tr>
</tbody>
</table>

- Data Flow: Crop conditions

| **Entity type:** Actual Crop status |
| **Attributes:** |
| development stage |

| **Entity type:** Crop |
| **Attributes:** |
| Crop code |
| Name |

| Relations: Actual Crop status describes the status of a Crop |

- Data Flow: planned observation

| **Entity type:** Observation |
| **Attributes:** |
| Status (plan., impl., carr.out) |
| planned date |

**Process:** Determine the crop conditions
Definition: Determine the crop conditions (e.g. development stage) at a given moment.

Is source of:
- Data Flow: Crop conditions
  Entity type: Actual Crop status
  Attributes:
    development stage

Is Destination of:
- Data Flow: Normative crop status
  Entity type: Normative crop status
  Attributes:
    Expected field emergence
    Expected field damage
    Development stage

Attributes:
- Crop code
- Name

Relations:
Actual Crop status describes the status of a Crop

Process: Determine the crop rotation plan

Definition: Determine the crop rotation plan for several cropping cycles.

Is source of:
- Data Flow: crop destination
  Entity type: Crop rotation plan
  Entity type: Crop
  Entity type: Field

Is Destination of:
- Data Flow: farming system
  Entity type: Farming system
  Attributes:
    Description

- Data Flow: subdivision of cult, area
  Attributes:

Relations:
Field is destined to Crop rotation plan
Crop belongs to Crop rotation plan

Process: Determine the observation crit.

Definition: Determine which criteria are relevant for an observation procedure. The criteria are based on:
- normative data;
- crop protection plan.

Process: Determine the production poss.

Definition: Determine the technical and (socio-) economic possibilities or conditions for production.
Process: **Determine the suitable prot. op.**

**Definition:** Determine a suitable protection operation taking into account the crop, available equipment, and restrictions for a specific tank mix.

<table>
<thead>
<tr>
<th>Is source of:</th>
<th>Is Destination of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Data Flow: suitable operations</td>
<td>- Data Flow: alternatives for a tank mix</td>
</tr>
</tbody>
</table>

**Entity type:** Operation

**Attributes:**
- name
- type of operation

<table>
<thead>
<tr>
<th>Is source of:</th>
<th>Is Destination of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Data Flow: soil &amp; field restrictions</td>
<td>- Data Flow: geographic data</td>
</tr>
</tbody>
</table>

**Entity type:** Field

**Attributes:**
- Field code
- Description
- Water catchment area (Y/N)

**Entity type:** Soil type

**Attributes:**
- organic matter content
- classification size of soil particles

**Relations:** Field is described by Soil type

**Process:** Divide cultivation area

**Definition:** Divide the farm into one or more plots and the plot into one or more fields.

<table>
<thead>
<tr>
<th>Is source of:</th>
<th>Is Destination of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Data Flow: subdivision of cult. area</td>
<td>- Data Flow: soil &amp; field restrictions</td>
</tr>
</tbody>
</table>

**Entity type:** Field

**Attributes:**
- Field code
- Description
- Water catchment area (Y/N)

**Entity type:** Soil type

**Attributes:**
- organic matter content
- classification size of soil particles

**Relations:** Field is described by Soil type

**Process:** Estimate dam. parasite/weed
Definition: Estimate the damage caused by the detected parasite using the figure for infestation pressure.

Is source of:
- Data Flow: estimated damage parasite/weed

Entity type: Product
Attributes:
- description of product
- status (planned, harvested, store)
- Yield capacity
- Expected yield loss

Is Destination of:
- Data Flow: growth rate

Entity type: Par * Pop. dyn. parameter
Attributes:
- event specific growth parameters
- infestation pressure

Process: Estimate damage prot. operation

Definition: Carrying out a crop protection operation can cause damage to the crop. Using a spraying machine in cereals will cause for example loss of grain yield by wheelings. Damage can also be caused by toxic effects of the chemical agents.

Is source of:
- Data Flow: estimated damage operation

Is Destination of:
- Data Flow: Actual weather conditions

Entity type: Actual weather conditions
Attributes:
- date of measurement
- time of measurement
- temperature
- vaporization
- relative humidity
- global radiation
- dew point
- figure for rainfall
- Period of registration

- Data Flow: Crop conditions

Entity type: Actual Crop status
Attributes:
- development stage

Entity type: Crop
Attributes:
- Crop code
- Name

Relations: Actual Crop status describes the status of a Crop

- Data Flow: actual soil condition

Entity type: Actual soil condition
**Process: Estimate the epid. growth**

**Definition:** Estimate or calculate the epidemic growth using parasite or weed specific growth parameters.

- Is source of:
  - Data Flow: growth rate
  
  *Entity type:* Par * Pop. dyn. parameter
  
  *Attributes:*
  - event specific growth parameters

- Is Destination of:
  - Data Flow: weed/par. specific growth pa.
  
  *Entity type:* Population dynamic parameter
  
  *Attributes:*
  - Relative growth rate
  - Leaf area index
  - Par * Pop. dyn. parameter

  *Entity type:* Parasite
  
  *Attributes:*
  - Name
  - Development stage
  - Weed
  
  *Relations:*
  - Parasite is described by Par * Pop. dyn. parameter
  - Par * Pop. dyn. parameter is described by Population dynamic parameter
  - Par * Pop. dyn. parameter describes Weed

- Data Flow: norm. weather data
  
  *Entity type:* Normative weather conditions
  
  *Attributes:*
  - average temperature
  - average figure for rainfall
  - average vaporization
  - average global radiation
  - average relative humidity

- Data Flow: normative crop data
  
  *Entity type:* Crop
  
  *Attributes:*
  - Crop code
  - Name
  - Scientific name

- Data Flow: actual soil conditions
  
  *Entity type:* Soil type

  *Entity type:* Field
**Process: Estimate the preventable loss**

**Definition:** The degree of potential loss caused by parasites and/or weeds which could be prevented is calculated for each suitable crop protection operation.

**Is source of:**
- Data Flow: total benefits of an operation

**Entity type:** Product

**Attributes:**
- description of product
- status (planned, harvested, store)
- expected price
- preventable yield loss

**Is Destination of:**
- Data Flow: efficacy of an operation
- Data Flow: estimated damage operation
- Data Flow: estimated damage parasite/weed

**Entity type:** Product

**Attributes:**
- description of product
- status (planned, harvested, store)
- yield capacity
- expected yield loss

**Process: Estimate the total costs**

**Definition:** Estimate the total costs for each suitable operation.

**Is source of:**
- Data Flow: figure for total costs

**Entity type:** Operation

**Attributes:**
- name
- expected total costs

**Is Destination of:**
- Data Flow: total costs equipment

**Entity type:** Operation

**Entity type:** Set of equipment

**Entity type:** Tangible fixed asset

**Relations:** Set of equipment is used by Operation

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Process: Evaluate crop protection activ.

Definition: The evaluation of all crop protection activities at operational level

Process: Examine the availability

Definition: Examine whether the recommended crop protection agent can be supplied from stock. Otherwise the farmer has to decide to buy the crop protection agent and he should know if the protection agent can be supplied in time for the operation.

Process: Form a paras./weed contr. pl.
Definition: A plan focused on the control of parasites and weeds taking into account several cultivation years.

Is source of:
- Data Flow: parasite control plan
  Entity type: Parasite control plan
  Attributes:
  - date
  - type of operation recommended

Entity type: Plot
  Attributes:
  - Plot code
  - Cadastral numbers
  - Description
  - location

Relations: Plot knows Parasite control plan

Is Destination of:
- Data Flow: weed control plan
  Entity type: weed control plan
  Attributes:
  - type of recommended operation
  - date

Entity type: Crop
  Attributes:
  - Crop code
  - Name

Entity type: Weed
  Attributes:
  - Name
  - Development stage

Relations: Crop knows Crop * parasite
Crop knows Crop * weed
Crop * weed belongs to Weed
Crop * parasite belongs to Parasite

- Data Flow: norm. occurrence par/weed
  Entity type: Norm. occurrence of a parasite/weed
  Attributes:
  - expected occurrence

Process: Form. a soil desinf. pl.

Definition: Formulate a soil desinfection plan taking into account several cultivation years.

Is source of:
- Data Flow: weed control plan
  Entity type: weed control plan
  Attributes:
  - type of recommended operation
  - date

Entity type: Plot
  Attributes:
  - Cadastral numbers
  - Description
  - location

Is Destination of:
- Data Flow: crop * weed/parasite relation
  Entity type: Crop * weed
  Attributes:
  - Crop code
  - Name

Entity type: Crop * parasite
  Attributes:
  - Name

Entity type: Crop
  Attributes:
  - Crop code
  - Name

Entity type: Weed
  Attributes:
  - Name
Process: Form. labour plan

Definition: Formulate a labour plan, taking into account all the operations which should be carried out taking into account several cultivation years.

Process: Form. manag. plan for cult.

Definition: Formulate a management plan which can be subdivided into plans for crop protection, fertilisation, harvest, sale and marketing, acquisition and treatment of parental material and auxiliary materials.

Process: Form. the objectives of the farm

Definition: Formulate the objectives of the farmer and the farm as a whole and per section.

Process: Harvest product

Definition: The harvest and store management of the product (potatoes, sugarbeet, grain etc.).

Process: Identify parasite or weed
**Definition:** Compare the observed characteristics with normative characteristics of parasites or weeds which can cause damage to the cultivated crop. The result of this process is a number of detected parasites and weeds.

**Entity type:** Operation

- **Attributes:**
  - name
  - type of operation
  - date of starting
  - date of ending
  - time of beginning
  - time of ending
  - main task period
  - speed of working
  - price or required labour
  - total price of required equipment
  - usage of tank mix

**Entity type:** Tank mix

- **Attributes:**
  - active ingredient
  - Name of tank mix
  - Status (prop., prep., sprayed)

**Entity type:** Crop protection agent

- **Attributes:**
  - Name of crop protection agent
  - average price (guild/kg)
  - Agent * mixture
  - Content of chemical act. agent

**Relations:**

- Tank mix is used by Operation
- Agent * mixture defines Tank mix
- Crop protection agent is part of Agent * mixture
- Crop protection agent contains Content of chemical act. agent

**Entity type:** Product

- **Attributes:**
  - description of product
  - status (planned, harvested, store)
  - Yield capacity
  - Expected yield loss

**Entity type:** Set of equipment

- **Attributes:**
  - code
  - type code
  - width of tyres
  - width of spraying arm

**Relations:**

- Tangible fixed asset is put on Set of equipment

**Entity type:** Field

- **Attributes:**
  - field code
  - Description
  - Water catchment area (Y/N)

**Entity type:** Soil type

- **Attributes:**
  - organic matter content
  - classific. size of soil particles

**Relations:**

- Field is described by Soil type

**Entity type:** Actual weather conditions

- **Attributes:**
  - date of measurement
  - time of measurement
  - temperature
  - vaporization
  - relative humidity
  - global radiation
  - dew point
  - figure for rainfal
  - Period of registration

**Entity type:** Actual Crop status
Attributes:
  development stage
Entity type: Crop
Attributes:
  Crop code
  Name
Relations: Actual Crop status describes the status of a Crop
- Data Flow: infestation prognosis
- Data Flow: environmental effects op.
Entity type: Environmental effects assessment
Attributes:
  Risk for persistence
  Risk for eluviation
  Toxicity to warm-blooded org.
  Toxicity to non-target org.
Entity type: Operation
Attributes:
  name
type of operation
Relations: Environmental effects assessment is caused by Operation
- Data Flow: stock
Entity type: Stock
Attributes:
  time of inspection of stock
  quantity in stock
Entity type: Crop protection agent
Attributes:
  Name of crop protection agent
  Content of chemical act. agent
Relations: Crop protection agent is available Stock
Crop protection agent contains Content of chemical act. agent
- Data Flow: Expected yield/price
Entity type: Product
Attributes:
  status (planned, harvested, store)
  expected price
  Yield capacity
- Data Flow: protection threshold
Entity type: Protection threshold
Attributes:
  limit weed density
  unit
- Data Flow: identified parasite/weed
Entity type: Weed * Symptoms
Attributes:
Process: Infestation prognosis

Definition: The prediction of the outbreak of an infestation for a specific point in time in a cultivation area or a crop.

Process: Implement crop protection meas.

Definition: Select, prepare and carry out a crop protection measure.
**Process:** Match the description

**Definition:** Match the descriptions of a parasite or weed with the normative descriptions of weeds and parasites in the crop. The result is an identified parasite or crop.

**Process:** Make an observation

**Definition:** Carry out an observation.

**Is source of:**
- Data Flow: Identified parasite/weed

**Entity type:** Weed * Symptoms

**Attributes:**
- Name
- Development stage
- Status (expected, estimated, count.)

**Entity type:** Parasite * Symptoms

**Attributes:**
- Name
- Development stage
- Status (expected, detected, count.)

**Is Destination of:**
- Data Flow: Symptoms

**Entity type:** Actual description weed symptoms

**Attributes:**
- Name
- Description of symptom

**Entity type:** Actual description parasite symptoms

**Attributes:**
- Name
- Description of symptom

**Is source of:**
- Data Flow: crop * weed/parasite relation

**Entity type:** Crop * weed

**Attributes:**
- Crop code
- Name

**Entity type:** Crop * parasite

**Attributes:**
- Crop code
- Name

**Relations:**
- Crop knows Crop * parasite
- Crop knows Crop * weed
- Crop * weed belongs to Weed
- Crop * parasite belongs to Parasite

**Is Destination of:**
- Data Flow: crop * weed/parasite relation

**Entity type:** Crop

**Attributes:**
- Crop code
- Name

**Entity type:** Weed

**Attributes:**
- Name
- Development stage

**Entity type:** Parasite

**Attributes:**
- Name
- Development stage

**Relations:**
- Crop knows Crop * parasite
- Crop knows Crop * weed
- Crop * weed belongs to Weed
- Crop * parasite belongs to Parasite

**Process:** Observe circumst. around farm

**Definition:** Observe conditions in the neighbourhood of the farm which can influence
the conditions for the crop protection on the farm.

**Process:** Plan an observation on weeds/par

**Definition:** Plan an observation aimed at determining the parasite or weed status in the crop.

Is source of: Is Destination of:  
- Data Flow: planned observation  
  Entity type: Observation  
  Attributes:  
  - Status (plan., impl., carr.out)  
  - Planned date

**Process:** Plan an prot. operation

**Definition:** Decide on the timing and reserve the necessary equipment for treatment.

Is source of: Is Destination of:  
- Data Flow: make an observation  
  - Data Flow: selected operation

**Process:** Plan crop protection measures

**Definition:** Plan how and when protection activities should be implemented, based on the normative and actual conditions.

Is source of: Is Destination of:  
- Data Flow: estimated damage parasite/weed  
  Entity type: Product  
  Attributes:  
  - Description of product  
  - Status (planned, harvested, store)  
  - Yield capacity  
  - Expected yield loss  
  - Data Flow: Actual weather conditions
  
  - Data Flow: Normative weather conditions  
  Entity type: Normative weather conditions  
  Attributes:  
  - Average temperature  
  - Average figure for rainfall  
  - Average vaporization  
  - Average global radiation  
  - Average relative humidity

- Data Flow: Actual weather conditions  
  Entity type: Actual weather conditions  
  Attributes:  
  - Date of measurement  
  - Time of measurement  
  - Temperature

- Data Flow: Normative crop status  
  Entity type: Normative crop status  
  Attributes:
**Process:** Plan the crop prot. progr.

**Definition:** Formulate a management plan for plant protection taking into account the widest range of circumstances which the crop may encounter, so that remedies to the problems which may arise have at least been considered.
**Process:** Prepare the land

**Definition:** Prepare the structure of the top soil and soil profile as required.

**Process:** Prepare the protection measure

**Definition:** Determine the suitable conditions and equipment for the implementation of protection measures (e.g. time, place, dosage, and equipment).

Is source of:  
- Data Flow: prepared operation

Is Destination of:  
- Data Flow: selected operation

**Process:** Prognosis potential damage

**Definition:** Loss prognosis seeks to assess the extent of expected economic loss in relation to the intensity of diseases or the weed densities or the population densities of a pest organism and the environmental and regulatory factors of significance to their development (Heitefuss, 1989).

**Comments:** Taking all circumstances into consideration, its aim is to decide in advance whether there is a risk of damage and whether control measures should be taken.
Expected yield loss

Attributes:
- Figure for infestation pressure
- Status (expect., detect., count.)

- Data Flow: norm. weather data
  Entity type: Normative weather conditions
  Attributes:
  - average temperature
  - average figure for rainfall
  - average vaporization
  - average global radiation
  - average relative humidity

- Data Flow: actual soil conditions
  Entity type: Soil type
  Entity type: Field
  Attributes:
  - Field code
  - location

Entity type: Crop rotation plan
  Attributes:
  - Status (planned, implemented)

Entity type: Actual soil condition
  Attributes:
  - Stock of freely avail. nitrogen

Relations:
- Field is destined to Crop rotation plan
- Field is described by Soil type
- Actual soil condition is known by Field

**Process:** Propose a tank mix

**Definition:** Compose an alternative tank mixture taking into account its efficacy for the identified parasites or weeds.
Process: Protect crops

**Definition:** All operational activities with the aim of protecting the crop against diseases, pests and weeds.

Process: Purchase of crop protection ag.

**Definition:** The purchase of crop protection agents needed for the control of pests, diseases and weeds.
**Attributes:**
- Name of crop protection agent
- Content of chemical act. agent

**Relations:**
- Crop protection agent is available Stock
- Crop protection agent contains Content of chemical act. agent

- Data Flow: supply

**Process:** Restrict number of prot. agents

**Definition:** If the tank mix is used in the early stage of the crop for the protection against weeds (called a soil herbicide), restrictions for soil type and water catchment area have to be taken into account.
Relations:

- Cropping protection agent contains Content of chemical act. agent
- Data Flow: identified parasite/weed
- Agent "mixture"
- Weed "agent"
- Parasite "agent"

Entity type: Weed * Symptoms
Attributes:
- Status (expected, estimated, count.)

Entity type: Parasite * Symptoms
Attributes:
- Status (expected, detected, count.)

Entity type: Weed
Attributes:
- Name
- Development stage

Entity type: Parasite
Attributes:
- Name
- Development stage

Relations:
- Weed is compared to Weed * Symptoms
- Parasite is compared to Parasite * symptoms

Process: Sow or plant

Definition: Sow or plant a variety in a designated field.

Process: Stock control for auxiliary mat.

Definition: Stock control of auxiliary materials

Is source of:
- Data Flow: stock

Entity type: Stock
Attributes:
- time of inspection of stock
- quantity in stock

Entity type: Crop protection agent
Attributes:
- Name of crop protection agent
- Content of chemical act. agent

Relations:
- Crop protection agent is available Stock
- Crop protection agent contains Content of
**Process:** Use the protection threshold

**Definition:** Determine which protection measures are economically beneficial
Appendix E Description of the data model

Entity type: Actual Crop status

Definition: Description of the crop status observed at a given moment according to specific characteristics. These include the morphological status (incl. stadium), physiological status (incl. growth stage, maturity), prevention of parasites and weeds.

Relationship:
- describes the status of a: Crop
- does influence: Probability of parasite/weed
- selects: Crop protection agent
- is described by: Normative crop status
- determines: Operation
- is delivered by: Observation

Attributes:
- development stage
- initial number of plants
- leaf area index
- plant density
- root zone
- field emergence
- frost damage

Entity type: Actual descript. parasite symp.

Definition: Gives an actual description of observed parasites. The description is used for the identification of a parasite.
Relationship:
compares Parasite * symptoms
is delivered by Observation

Attributes:
  name
  description of symptom

Entity type: Actual description weed symptoms

Definition: Gives an actual description of the symptoms of a crop. The description is used for the identification of the parasite.

Relationship:
compares Weed * Symptoms
is delivered by Observation

Attributes:
  name
  description of symptom

Entity type: Actual soil condition

Definition: The soil condition at the time of observation.

Relationship:
is known by Field
is delivered by Observation
depends on Par * Pop. dyn. parameter
effects Probability of parasite/weed
determines Operation
Attributes:
- soil moisture
- rainfall
- rainfall distribution
- fraction of soil part. <2um
- lime unit
- organic content
- fraction of stones
- workability
- soil temperature
- occurrence of clods
- incidence of mechanical damage
- Stock of freely avail. nitrogen

Entity type: Actual weather conditions

Definition: The weather conditions at the time of observation.

Relationship:
effects are classified Probability of parasite/weed

determines Normative weather conditions

determines Parasite * agent

determines Weed * agent

determines Operation

is delivered by Observation

Attributes:
- date of measurement
- time of measurement
- temperature
- vaporization
- wind speed

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wind direction
relative humidity
global radiation
dew point
rainfall
period of registration

Entity type: Agent * mixture

Definition: Indication that a number of protection agents are compatible and can be mixed by the farmer himself without giving undesirable reactions. Undesirable reactions are for example:
- a reduction in efficacy on parasites or weeds to be controlled;
- certain mixtures cause damage to the crop;
- certain mixtures clog nozzles;
- certain mixtures can give unexpected chemical reactions.

Relationship:
defines Tank mix
consists of Crop protection agent

Attributes:
dose of agent

Entity type: Chemical active ingredient

Definition: The chemical ingredient of a crop protection agent which determines the efficacy of an agent on a parasite or weed.

Relationship:
is part of Content of chemical act. agent
Attributes:

- name of active ingredient
- chemical formula
- solubility in water
- chemical category
- mode of action
- toxicity
- minimum organic content
- maximum organic content
- minimum silt content
- maximum silt content

Entity type: **Content of chemical act. agent**

**Definition:** Content of a specific chemical active agent as part of a crop protection agent.

**Relationship:**

- is specified by Crop protection agent
- specifies Chemical active ingredient
- causes Environmental effects

Attributes:

- content
- dimension

Entity type: **Crop**

**Definition:** A collection of cultivated plants which are grown as an entity in one field or several adjacent fields.
### Attributes:

| crop code | name | scientific name |

### Entity type: Crop * parasite

**Definition:** Determines the specific relationship between a parasite and host (the cultivated crop).

### Relationship:

<table>
<thead>
<tr>
<th>belongs to</th>
<th>restricts</th>
<th>belongs to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasite</td>
<td></td>
<td>Crop</td>
</tr>
</tbody>
</table>

### Entity type: Crop * weed

**Definition:** Determines the relationship between weed and host (the cultivated crop). If these relations exist, it means that a weed can cause damage to a crop.
Relationship:

belongs to Weed
restricts weed control plan
belongs to Crop

Entity type: Crop protection agent

Definition: Chemicals applied for the control of pests, diseases or pests.

Relationship:

is part of Agent * mixture
can be sold as Trademark
contains Content of chemical act. agent
is restricted by Field
is available Stock
is described by Actual Crop status
controls Parasite * agent
controls Weed * agent

Attributes:

name of crop protection agent
efficacy
lower limit for organic content
upper limit for silt content
upper limit for organic content
lower limit for silt content
average price (guild./kg )
residual activity period agent

Entity type: Crop rotation plan

Comments: Previous rotational history or planned rotation of different crops on
different fields. Concerning crop protection it gives an indication of possible sources of infection or infestation. The choice of crop protection may also be restricted because of residues which do effect the next crop.

Relationship:
- situates Observation
- belongs to Field
- is destined to Crop

Attributes:
- sowing date
- year of implementation
- planned year
- status (planned, implemented)

Entity type: Environmental effects

Definition: Effect (negative) of an operation (e.g. crop protection) on the environment.

Relationship:
- is caused by Operation
- is caused by Content of chemical act. agent

Attributes:
- risk for persistence
- risk for eluviation
- toxicity to warm-blooded org.
- Toxicity to non-target org.

Entity type: Farm

Definition: An independent production organization which endeavours through the
sale of products to earn an income which is such that in the longer term the income will exceed the costs and thereby guarantee continuity.

**Relationship:**

consists of Plot

**Attributes:**

- name
- place of business
- postal address street
- postal address house number
- postal address post box
- postal address municipality
- telephone number
- type of farm

**Entity type: Farming system**

**Definition:** Defines the cultivation purpose (e.g. for animal feed, seed propagation) and objects of the farming (e.g. non use of chemical agents).

**Relationship:**

describes variety * farming system

**Attributes:**

- description
- type of production system

**Entity type: Field**

**Definition:** A continuous piece of land, considered to be homogeneous by the farmer with regard to soil type, production capacity, crop rotation plan, history and other
requirements of the farmer. Different crops are usually grown consecutively in a field.

**Relationship:**

- is part of: Plot
- is destined to: Crop rotation plan
- is described by: Soil type
- knows: Actual soil condition
- knows: Planned soil condition
- restricts: Crop protection agent

**Attributes:**

- field code
- description
- location of field
- shape of field
- length
- width
- water catchment area (y/n)
- location
- area

**Entity type:** host * parasite

**Definition:** Defines the relation between a host and parasite

**Relationship:**

- describes: Parasite
- describes: Variety

---

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Entity type: Norm. occurrence of a parasite/we

Definition: Normative occurrence of a parasite or weed as relation of crop and weather data.

Relationship:
- is influenced by Normative crop status
- is effected by Normative weather conditions
- predicts Probability of parasite/weed

Attributes:
- expected occurrence

Entity type: Normative crop status

Definition: Description of the status expected at a given moment according to specific characteristics. These include the morphological status (incl. growth stage), and maturity.

Relationship:
- describes Actual Crop status
- influences Norm. occurrence of a parasite/we
- describes Crop

Attributes:
- expected field emergence
- expected field damage
- development stage

Entity type: Normative weather conditions

Definition: Description of the state of environment which can be expected at a given
moment at a certain location according to specific characteristics.

Relationship:
effects
effects
classifies
determines

Attributes:
  average temperature
  period of measurement
  average figure for rainfall
  average vaporization
  average global radiation
  average relative humidity

Entity type: Observation

Definition: Assess the actual conditions which have an important bearing on decisions regarding crop protection operations.

Relationship:
on
delivers
delivers
delivers
delivers
delivers
is type of
is determined by
delivers

Crop
Actual descript. parasite symp.
Actual description weed symptoms
Parasite * symptoms
Actual Crop status
Actual weather conditions
Weed * Symptoms
Operation
Operation
Actual soil condition
is situated at Crop rotation plan

Attributes:
- date of observation
- status (plan., impl., carr.out)
- planned date
- Implemented date
- date carried out
- limiting weather specifications
- description of procedure

Entity type: Operation

Definition: A technically cohesive aggregate of activities whereby at a given moment a characteristic status of a specific object (e.g. field, crop, building, machine) is observed, carried out, or prevented.

Comments: Possible values in context of crop protection are:
- spraying all over the field;
- spraying the rows;
- spraying by plane.

Relationship:
- is type van Observation
- is determined by Actual soil condition
- is determined by Actual Crop status
- is determined by Normative weather conditions
- determines Observation
- is carried out for Crop
- estimates Yield loss
- causes Environmental effects
- is determined by Actual weather conditions
is determined by Protection threshold
estimates Product

Attributes:
  name
  type of operation
  efficacy
  status (planned, prep, carr. out)
  date of starting
  date of ending
  time of beginning
  time of ending
  work method instruction
  net area of cultivation
  task period
  main task period
  speed of working
  desired experience of applier
  repetition
  price or required labour
  total price of required equipm.
  efficacy for type of operation
  expected total costs
  expected total benefits
  usage of tank mix

Entity type: Par * Pop. dyn. parameter

Definition: Defines the set of population dynamic parameters for the estimation of damage caused by a specific parasite or weed.
Relationship:
is described by Population dynamic parameter
describes Weed
describes Parasite
describes Crop
describes Soil type
describes Normative weather conditions
describes Actual soil condition

Attributes:
  event specific growth parameters

Entity type: Parasite

Definition: An organism that obtains its nutrients wholly or partly from another living organism and may cause damage to the crop.

Relationship:
known as a parasite of Crop
ex1 causes Yield loss
is compared to Parasite * symptoms
is described by Par * Pop. dyn. parameter
is controlled by Parasite * agent
knows Crop * parasite
has a Protection threshold
has host * parasite

Attributes:
  name
  scientific name
  protection threshold
  development stage
**Entity type**: Parasite * agent

*Definition*: Defines the permission of using a certain crop protection agent in a specific crop.

*Relationship*:
- is controlled by Crop protection agent
- is controlled by Parasite
- is determined by Actual weather conditions

**Entity type**: Parasite * symptoms

*Definition*: Matches all the normative symptoms to the described symptoms as result of an observation. The result is an identified parasite.

*Relationship*:
- can cause Product
- can cause Yield loss
- compares Parasite
- is compared to Actual descript. parasite symp.
- is delivered by Observation

*Attributes*:
- initial population
- figure for infestation pressure
- status (expect., detect., count.)

**Entity type**: Parasite control plan

*Definition*: A strategy for the control of parasites taking into consideration several cultivation years.
Relationship:
is defined for          Plot
is restricted by       Crop * parasite

Attributes:
  date
  type of operation recommended

Entity type: Planned soil condition

Definition: Planned soil necessary for the implementation of specific operation.

Relationship:
is known by              Field

Entity type: Plot

Definition: A continuous piece of land consisting of one or more fields belonging to the arable farm.

Relationship:
knows                     Parasite control plan
consists of               Field
belongs to                Farm
has a                     weed control plan

Attributes:
  plot code
  cadastral numbers
  description
  location
  area
length
width

*Entity type:* Population dynamic parameter

*Definition:* A specific parameter used for describing the growth of crops, parasites and weeds.

*Relationship:*

Estimation damage  parasite/weed
is used for  Par * Pop. dyn. parameter

*Attributes:*

- relative growth rate
- leaf area index

*Entity type:* Probability of parasite/weed

*Definition:* The probability that a certain parasite or weed is present in the crop.

*Relationship:*

is predicted by  Norm. occurrence of a parasite/we

determines the need of  Observation

is influenced by  Actual Crop status

is effected by  Actual weather conditions

is effected by  Actual soil condition

*Entity type:* Product

*Definition:* A consignment of plants or parts of plants which are the result of harvesting or processing.
Relationship:
has an Yield loss
is estimated by Operation
is influenced by Yield loss
is caused by Weed * Symptoms
is caused by Parasite * symptoms

Attributes:
- product consignment code
- product type
- description of product
- date of delivery
- description of quality
- status (planned,harvested,store)
- expected price
- realized price
- realized yield
- yield capacity
- expected total yield loss
- preventable total yield loss
- name/description


determine the actual environm.

Entity type: Protection threshold

Definition: Economic threshold based on the prognosis of yield reduction caused by a specific density of weeds or parasites. A prerequisite is experimental research into the relationship between weed density and yield.

Relationship:
is determined by Yield loss
is defined for Weed

108
determines Operation
is defined for Parasite

Attributes:
    limit weed density
    unit

Entity type: Set of equipment

Definition: All the equipment needed for an operation.

Relationship:
is used by Operation
uses Tangible fixed asset

Entity type: Soil type

Definition: The classification of soil types using physical parameters.

Relationship:
effects Par * Pop. dyn. parameter
describes Field

Attributes:
    available water capacity
    pH
    occurrence of clods
    organic matter content
    incidence of mechanical damage
    classification of soil texture
    classific.size of soil particles
Entity type: Stock

Definition: The quantity of parental material, auxiliary material or product at a specific date.

Relationship:
- consists of Trademark
- contains Crop protection agent

Attributes:
- time of inspection of stock
- quantity in stock
- dimension

Entity type: Tangible fixed asset

Definition: Production resource which is administered by the farm or hired, and can be used for production over a period of several years.

Comments: In the field of crop protection the following entities are relevant:
- spraying machine;
- dutch hoe etc.;

Relationship:
- is put on Set of equipment

Attributes:
- code
- type code
- width of tyres
- width of spraying arm
**Entity type:** Tank mix

**Definition:** The use of one protection agent in combination with other agents. The tank mix is made by the farmer himself.

**Comments:** Motives for preparing tank mixes:
- giving efficacy against a bigger range of parasites or weeds;
- less sprayings resulting in the decreasing need of labour and lower costs

**Relationship:**
- is used by Operation
- is determined by Agent * mixture

**Attributes:**
- active ingredient
- compound waiting period
- name of tank mix
- efficacy
- status (proposed, prepared, sprayed)
- residual activity period of mix

**Entity type:** Trademark

**Definition:** The trade name of a chemical protection agent given by the supplier.

**Relationship:**
- is part of Stock
- belongs to Crop protection agent

**Attributes:**
- name
- permission (yes/no)
permission number
name of company
name of supplier
indication of specific risks
starting date of permission
ending date of permission
mutation date of permission
only on prescription (Y/N)

**Entity type: Variety**

*Definition:* A group of plants belonging to a crop which can be considered as independent unit.

*Relationship:*
- belongs to: variety * farming system
- has a: host * parasite
- is part of: Crop

**Entity type: variety * farming system**

*Definition:* The relationship which defines if a variety is can be applied for a specific farming system.

*Relationship:*
- is part of: Farming system
- describes: Variety

**Entity type: Weed**

*Definition:* A type of plant which can cause yield reduction to the cultivated crop.
Relationship:
ex1 causes an Yield loss
is compared to Weed * Symptoms
is controlled by Weed * agent
known as a weed of Crop
has Crop * weed
has a Protection threshold
is influenced by Par * Pop. dyn. parameter

Attributes:
  - name
  - scientific name
  - protection threshold
  - development stage

Entity type: Weed * agent

Definition: Defines the permission of using a specific crop protection agent in a specific crop.

Relationship:
is controlled by Crop protection agent
is controlled by Weed
is determined by Actual weather conditions

Entity type: Weed * Symptoms

Definition: Matches all the normative symptoms with described symptoms. The result is an detected weed.

Relationship:
are delivered by Observation
can cause  Product
can cause  Yield loss
comparis  Weed
is compared to  Actual description weed symptoms

**Attributes:**
- number of detected weeds
- figure for infestation pressure
- status (expect, estimat., count.)

**Entity type:** weed control plan

**Definition:** Strategy for the control of weeds taking into consideration several cultivation years.

**Relationship:**
- is defined for  Plot
- is restricted by  Crop, weed

**Attributes:**
- type of recommended operation
- date

**Entity type:** Yield loss

**Definition:** Yield loss caused by one detected weed, parasites or operation.

**Relationship:**
- is caused by  Parasite, symptoms
- is caused by  Weed, Symptoms
- is estimated by  Operation
- influences  Product
is caused by Weed
is caused by Parasite
defines Protection threshold
is calculated with Product

Attributes:
infestation figure
morphological status
physiological status
figure for expected yield loss
figure for observed yield loss
prevented yield loss
Content of chemical act. agent 57, 85-87, 94
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  bevat op de praktijk gerichte akkerbouw- en algemene informatie
- akkerbouw-totaal:
  bevat naast de op de praktijk gerichte informatie ook gedetailleerde onderzoekinformatie m.b.t. akkerbouw
- vollegrondsgroente-praktijk:
  bevat op de praktijk gerichte vollegrondsgroente- en algemene informatie
- vollegrondsgroente-totaal:
  bevat naast de op de praktijk gerichte informatie ook gedetailleerde onderzoekinformatie m.b.t. de vollegrondsgroenteteelt
- totaal-praktijk:
  bevat op de praktijk gerichte informatie, zowel voor de akkerbouw als voor de vollegrondsgroenteteelt
- totaal-verslagen:
  bevat indirect wel praktijkgerichte informatie, maar bestaat in principe uit gedetailleerd onderzoekinformatie, zowel voor de akkerbouw als voor de vollegrondsgroenteteelt
- totaal-PAGV:
  bevat alle PAGV-uitgaven.

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