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Deliverable 3.4: Information models specifying usage processes and data elements

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

1 Introduction

In the first deliverable of WP3 (deliverable 3.1; Sørensen *et al*., 2009a), an outline of the essential entities and boundaries of the proposed information system were defined. The second deliverable of WP3 (deliverable 3.2; Sørensen *et al*., 2009b) focused on material and information flows and provided the relevant flow diagrams for six central field tasks which were suitable for generalisation. These tasks were: tillage, seeding, fertilising, spraying, irrigation and harvesting. Next, the third deliverable of WP3 (deliverable 3.3; Pesonen *et al*., 2009) described the knowledge and information to be encoded in the FMIS based on a thorough analysis of the fertilising operation. More specifically, the information flows and relevant input data were given for the strategic, tactical and operational planning of the fertiliser operation, as well as its execution and evaluation. The information flow diagrams included the actors and usage processes involved in the overall operation, and specified which information must be encoded in the system, provided by partner/actors, and produced by the system.

In this paper, the focus is on the content of the "Process" boxes of the information flow model which represent the usage processes of the information and on the "Information" boxes which represent the data elements.

By decomposing the activities inherent in the six field operations, the information, processes and information producers (actors) involved in the decision making were recorded and described in WP3 (deliverable 3.2 (Sørensen *et al* 2009b). A process receives data, transforms it and produces a result. An external entity is a source of data used in the model. A data store is a location, where data are temporarily or permanently stored in the system. A data flow is a transfer of data between the various components of the system. The information flow diagrams included the actors and usage processes involved in the overall operation, and specified which information must be encoded in the system, provided by partner/actors, and produced by the system (Figure 1).

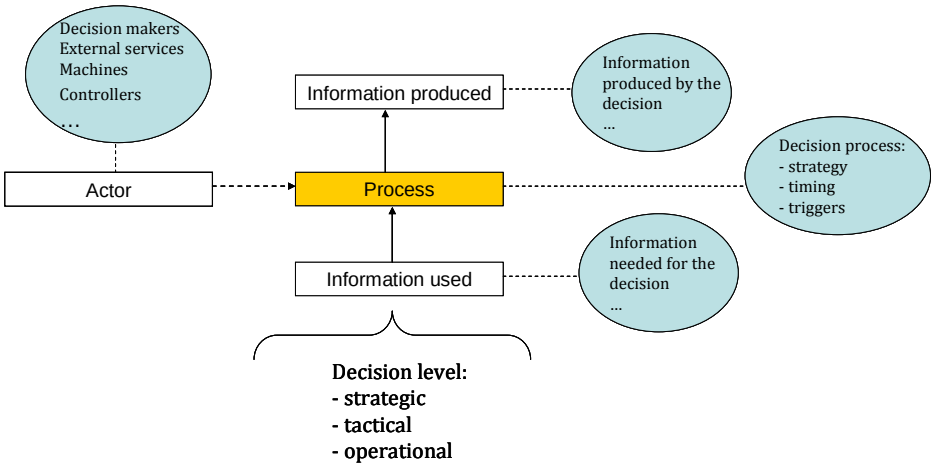

Figure 1. Information flow modelling approach

2 Usage processes

The content of information usage processes will be presented as the nature of the decision making process. The usage processes are typically complex decision making processes which require information from several sources as input. The decisions are taken by the farmer or farm manager. The knowledge in the usage process can be well structured and modelled, following a set of defined rules. In this case, automated or semi-automated assistance can be provided. However, in most cases, the decisions are based on tacit knowledge.

Well structured decision making follows certain rules which have to be provided to the decision processes (deliverable 4.1.1; Nash *et al* 2009). Beside rules, input information entities, or data elements contain attributes. An example of the content of information input entities of Execution level decisions is described in Table 2 and 3. The table presents the definition of the entity, attributes related to it, availability of the attributes at the moment and the future requirements for their availability. Information needed in the decision processes of precision agriculture is spatial in the operational, execution and evaluation levels.

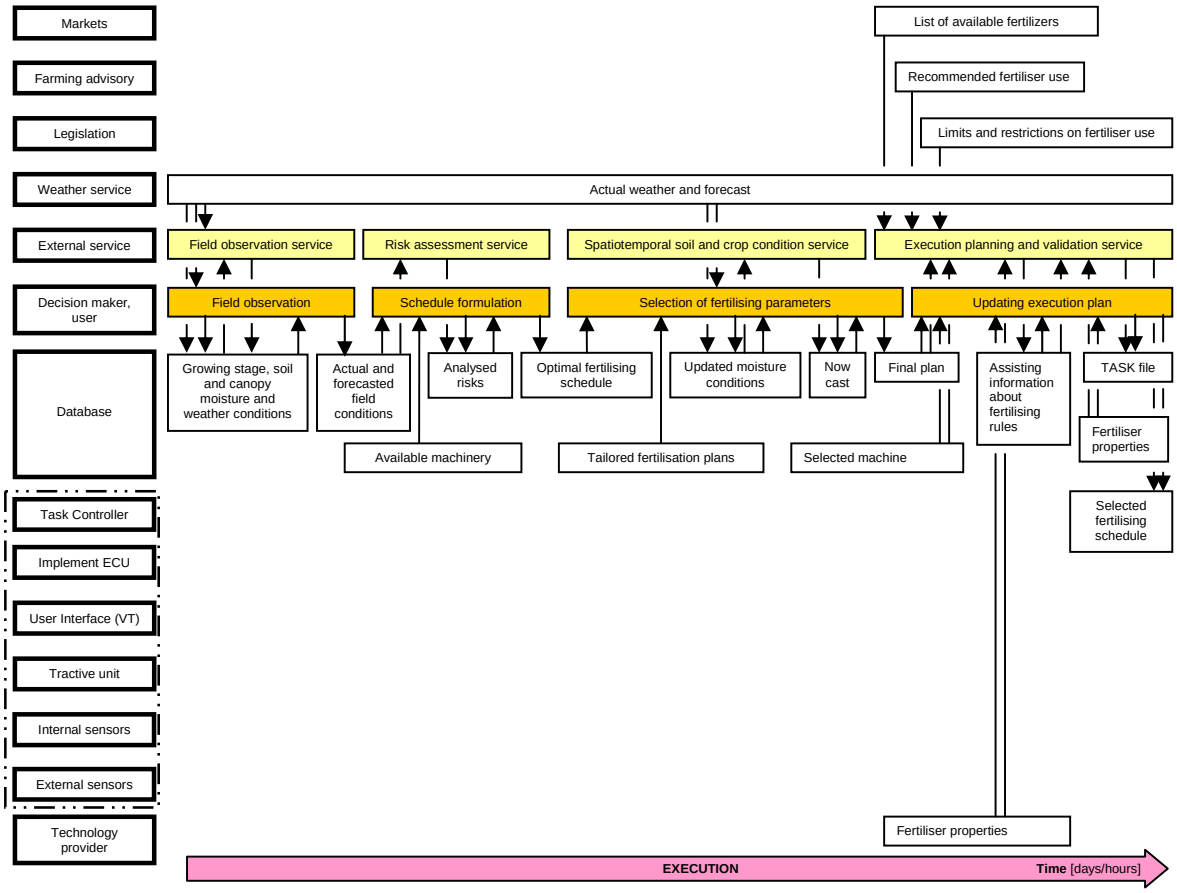

Figure 2. An example of the information flow model presenting a part of Execution decision level sage processes and information inputs.

The next step is to open up the usage or decision processes and describe their knowledge content as well as their level of the assessed level of automation. Table 1 gives a description of the decision processes associated with the fertilizing operation.

Table 1. Description of decision processes

Decision process	*Description of the decision process*	*Level of automation*
Future farm vision	Determining the overall long-term production vision of the farm based on internal and external preferences and possibilities	Manual
Whole farm planning	Determining the overall production strategy and production composition of the farm based on internal and external preferences and possibilities	Manual
Formulating the fertilizing strategy	Determining the overall fertilising strategy of the farm based on internal and external preferences and possibilities	Manual
Choosing fertilizing technology: information and machinery	Selection the best adopted fertilising technology based on the expected production possibilities and constraints for the coming years	Manual
Selecting fertilizing features	Selection the best fertilising technology based on the feature components available on the market	Manual
Acquiring planning information	Determining and selection of the necessary planning information and the selection of the possible assisting services	Manual
Fertilizing process planning	Determining the overall fertilizer work plan by taken into all available information (required fertilizer, available fertilizer, etc.)	Manual
Selecting final data acquisition service	Selecting the final data acquisition services to be used	Manual
Field inspection	Observation/data acquisition on field conditions	Manual/semi-automatic
Formulating execution plan	Determining the actual execution plan in terms of expected schedule for the fertilizing task	Manual
Field observation	Determining the actual condition of the field in terms of soil and weather	Manual/semi-automatic
Schedule formulation	Determining the optimal fertilizing schedule based on expected growing and weather conditions as well as associated risks	Manual/semi-automatic
Selection of fertilizing parameters	Determining the final fertilizing parameters to be part of the final plan	Manual
Updating execution plan	Determining the final execution based equivalent to the TASK file based on the latest available information	Manual/semi-automatic
Selection of fertilizing parameters	Determining the fertilizer parameters based on the current online updating of all available information	Manual/semi-automatic/fully automatic
Inspecting and controlling fertilizing task	Determining the progress of fertilizer task as compared with the planning	Manual/semi-automatic/fully automatic
Finishing or reformulating execution plan	Determining to whether to reformulate the current execution plan or not	Manual/semi-automatic/fully automatic
Data processing for documentation	Determining the data types, aggregation, etc. necessary in order to document the execution	Manual/semi-automatic/fully

		automatic
Compliance to standard check	Determining if the executed task comply with standards or other guidelines	Manual/semi-automatic/fully automatic
Summarizing fertilizing performance	Determining the current fertilizer work performance based on the recoded data on machinery, soil and weather conditions	Manual/semi-automatic/fully automatic
Comparison to target	Determining the possible difference between actual performance and planned target	Manual/semi-automatic/fully automatic

3 Data elements

In the context of the information modelling approach, the decision processes described in Section 2 requires information as input and produces information as an output from the decision process. Further decomposition of these information flows by describing the data content. Table 2 gives a description of the data content in the fertilizing case and involving quality and quantity**,** spatial aspect and rules, etc.

Table 2. Data description for the execution level

Entity	*Definition*	*Attributes/data*	*Availability of data*	*Future requirements*
Actual weather and forecast	Current weather and short term forecast	- type of weather parameter (e.g. temperature, wind, humidity, precipitation) - parameter value - forecast probabilities (e.g. coming changes in weather type)	- current weather on field/parcel level - forecast on regional level	- forecast on field/parcel level - onboard measurement of current weather (e.g autonomous units)
Growing stage, soil and canopy moisture and weather conditions	Description of current growing stage, soil and canopy moisture and weather conditions in the field	- field ID - current growth stage - soil and canopy moisture - weather data (e.g. precipitation, temperature, wind speed)	- sensor networks for data transfer - imageries data acquisition with manual interpretation	- imageries data acquisition with automated interpretation
Actual and forecasted field conditions	Current status of field and crop workability	- field ID - status of the growth - type of observation (e.g. nutrient deficiency, LAI, soil moisture) - attribute values - forecast probabilities (e.g. workable time)	- automated data acquisition with automated interpretation exist but in proprietary format	- automated data acquisition and interpretation with open systems and standard format
Available machinery	Description of currently available machinery	- list of available machines (machine type, machine ID, machine DCD-file)	- available by manual creation	- automated downloading of DCD-file to the FMIS
Analysed risks	Description of	- probability of	- weather probability on	- weather probability on

	analysed and defined risks concerning fertilising scheduling	unexpected weather - probability of unexpected availability of machinery - probability of unexpected crop condition	regional level - sparse reliability data available - non automated warning functions for e.g pests	field/parcel level - improve reliability data by automated performance documentation -automated warning functions for e.g pests
Optimal fertilising schedule	The optimal fertilizing schedule for implementation	- expected time of executing fertilising operations - expected rate to be applied - workable weather conditions (acceptable rain, temperature, soil moisture, etc.)	- ad-hoc manual decision making - applied rate based on norms - manual measurements and experiences/interpretation for decision making	- automated decision support system - applied rate based on spatial measurements - automated measurements and decision support function for decision making
Updated moisture conditions	Description of current moisture information in the field	- field ID - soil moisture - canopy moisture	- soil sensor networks for data transfer - local weather station network for data transfer	- automated measurements and decision support function for decision making - automated moisture prediction models
Nowcast	Updated short term weather forecast	- type of weather parameter (e.g. temperature, wind, humidity, precipitation) - parameter value - forecast probabilities (e.g. coming changes in weather type)	- nowcast weather available on regional level - nowcast weather probabilistic available on regional level	- automated nowcast weather service for field/parcel level - automated nowcast weather probability service for field/parcel level
Final plan	Selected fertilisation plan for a specific field	- plan ID - field ID - application rate - application map - amount of nutrients per site (N, P)	- manual creation of final plan	- automated creation of final plan
List of available fertilizers	Available fertilisers on the market	- type of fertiliser - operational instructions and restrictions - content of nutrients - price of fertiliser	- available on demand	- automated updating of fertiliser attributes to downloading the FMIS
Recommended fertiliser use	Description of recommended fertiliser use	- type of fertiliser - timing - amount of fertiliser - splitting of fertilising - expected effect of fertiliser	- available on demand	- automated updating of fertiliser use recommendations
Fertilizer properties	Description of the properties of the available fertilisers provided by technology provider	- type of fertiliser - name of the fertiliser - name of the supplier - origin of the fertiliser - nutrient content - chemical compound - safety period	- available on demand	- automated updating of fertiliser properties to the FMIS
Assisting	Assisting	- relevant rules for type	- available on demand	- automated updating of

information about fertilising rules	information about farm-specific fertilising rules provided by external service	and amount of fertiliser, timing, allowed locations, costs - choices - warnings		fertilising rules to the FMIS
Limits and restrictions on fertilizer use	Description of legislative restrictions for fertiliser use	- fertiliser type - application amount - allowed application location - timing - application method	- available on demand	- automated updating of limits and restrictions on fertilizer use to the FMIS
Fertilizer properties	Description of the properties of the selected fertilisers stored in the farm database	- type of fertiliser - name of the fertiliser - name of the supplier - origin of the fertiliser - nutrient content - chemical compound - safety period	- available by manual creation	- automated downloading of fertilising properties to the FMIS using RFID technology
Selected machine	Technical information of selected machine	- machine ID - Device Configuration Data (DCD)	- available by manual creation	- automated downloading of DCD-file to the FMIS
TASK file	Description of control settings for the fertilising machine and operation	- field ID - date - worker ID - type of setting (fertiliser 1… n, nominal rate (default value), machine set-up, driving speed (default value), working height and width, documented parameters, variable rate application (VRA) map) - control setting values for the specified types of settings	- available by manual creation	- automated creation of TASK-file in the FMIS
Selected fertilising schedule	Description of the selected fertilising schedule	- field ID - expected time of executing fertilising operations - expected application rate - workable field conditions (weather and soil moisture constraints)	- available by manual creation	- automated decision support function for choosing optimal fertilising schedule
Figure 7				
TASK values	Control setting values for the fertilising machine and operation	- control setting values for the specified types of settings; nominal rate (default value), machine set-up, driving speed (default value), working height and width, documented	- available based on user inputs	- automatic downloading to implement ECU

		parameters, variable rate application (VRA) map)		
Set ups	Calibration for internal sensors	- sensor ID - type of calibration - calibration values	- manual measurements	- automatic calibration functions
Assisting information for driver	Guidelines shown for tank filling and machine settings	- field ID - confirmation of correct match of machine ID and task file ID - type of setting (fertiliser 1… n, nominal rate, machine set-up, driving speed, working height and width, documented parameters, variable rate application (VRA) map) - control setting values for the specified types of settings - type of weather parameter - parameter value (e.g. temperature, wind, humidity, precipitation)	- available on demand	- available on demand
Updated parameters	Updated parameters for the task controller by the operator	- field ID - date - worker ID - type of setting (fertiliser 1… n, nominal rate (default value), machine set-up, driving speed (default value), working height and width, documented parameters, variable rate application (VRA) map) - control setting values for the specified types of settings	- available based on user inputs	- automatic generation of updated parameters
Updated parameters	Updated parameters for the fertiliser machine's ECU by the operator or/via the Task Controller	- machine ID - calibrations - machine specification - automation specification - type of setting (fertiliser 1… n, nominal rate (default value), machine set-up, driving speed (default value), working height and width, documented parameters, variable	- available based on user inputs	- automatic generation of updated parameters

		rate application (VRA) map) - control setting values for the specified types of settings		
Selected machine parameters	Selected machine parameters stored in database	- field ID - machine ID - worker ID - type of setting (fertiliser 1… n, nominal rate, machine set-up, driving speed, working height and width, documented parameters, variable rate application (VRA) map) - control setting values for the specified types of settings - calibrations - machine specification - automation specification	- available automatically	- automatic selection of machine parameters
Selected machine parameters	Selected machine parameters shown in virtual terminal	- field ID - machine ID - type of setting (fertiliser 1… n, nominal rate, machine set-up, driving speed, working height and width, documented parameters, variable rate application (VRA) map) - control setting values for the specified types of settings - calibrations - machine specification - automation specification	- available automatically	
Fertilising status information	Description of fertilising process status	- field ID - worker ID - machine ID - type of setting (fertiliser 1… n, nominal rate, machine set-up, driving speed, working height and width, documented parameters, variable rate application (VRA) map) - control setting values for the specified types of settings	- available automatically	

		- alarms and warnings - automation sequences - automation/manual drive		
Raw data	Monitoring data fron the external sensors and documentation of control realisation	- type of operational parameter - value of operational parameter - logging frequency	- automatically generated	
Monitoring information	Monitoring data from the external sensors	- type of operational parameter - value of operational parameter - logging frequency	- automatically generated	
Status information	Description of tractive unit status	- type of tractive unit parameters (e.g. fuel consumption, driving speed, pto) - values of parameters - logging frequency	- automatically generated	
Process information	Control information from internal sensors measuring work unit performance	- type of operational parameter - value of operational parameter - logging frequency	- automatically generated	
Operation status and documented execution data	Current operation status	- machine ID - aggregated process information - current realised work performance compared to planned capacity (ha/h) - current operation progress compared to schedule - remaining fertilizing work - recorded monitoring information (e.g. soil moisture, biomass values, etc.)	- automatically generated	
Fine tuned task	Fine tuning certain task parameters during the execution	- selected task file parameters - new set values	- available based on user inputs	- automatically generation of parameter for parameters tuning
Overall task monitoring	Real-time status information and adjustments shown in the virtual terminal	- field ID - date and time - worker ID - machine ID - aggregated process information - current realised work performance compared to planned capacity	- automatically generated	

		(ha/h) - current operation progress compared to schedule - remaining fertilizing work - recorded monitoring information (e.g. soil moisture, biomass values, etc.) - fertilising process adjustments		
Documented execution data	Description of summary data for execution	- field ID - date and time - worker ID - machine ID - aggregated process information - summarised realised work performance (ha/h) - summarised amount of applied fertilisers - summarised operation progress compared to schedule - remaining fertilising work - summarised recorded monitoring information (e.g. soil moisture, biomass values, etc.) - notes for fertilising process adjustments	- automatically generated	

4 Summary and Conclusions

Information flow models presented in D3.2 show the information usage processes, so called decision processes, information inputs needed and also the actors responsible for delivering or using the information. The content of each usage process and information input can be described accurately, either in a way the reality is at the moment or in a way we wish the reality to be in the future. Each actor can determine the needs and requirements set to them and act accordingly.

This deliverable have identified the content of the “Process” boxes of the information flow model which represent the usage processes of the information and on the “Information” boxes which represent the data elements. The description of the data content in the fertilizing case has involved quality and quantity**,** spatial aspect and rules, etc.

The identification of the usage processes as well as the data elements have shown the complexity of the decision making process within the agricultural domain. In fully structured and formalised information flow decomposition, many actors are required to deliver information to the decision processes in order to fully

emulate the tacit knowledge that farmers and decision makers are currently using. Especially, the concept of assisting services has to evolve in order to sustain the need of more automated decision processes.

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