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Yield Mapping:
Principles and System Components

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Yield is important to any crop producer, as it ultimately determines the profitability of an enterprise. While yield is normally thought of on a per acre basis, it is usually determined by dividing the total yield from a field (pounds of lint, bushels of grain, etc.). the area of that field. If all portions of a field were equal then this calculated value would accurately represent the unit area yield over the entire field. Unfortunately, that is not typically the case. Yield varies within a field for a variety of reasons such as soil variability, water, and diseases. Most producers know that yield variability exists, but they do not know the actual magnitude of the yield variability or the size of areas that differ in yield.

Yield mapping is a technique in which the actual yield is measured across the entire field. By measuring the yield at each location within the field, a better picture can be obtained of the field's true variability. With the aid of this picture, the source and economic impact of that variability can be determined. Yield mapping is now possible for many crops through the application of technologies such as satellite positioning and geographic databases. This document will explain the basic principles of yield mapping and the yield mapping system components.

YIELD MAPPING SYSTEM PRINCIPLES:

The underlying principle of yield mapping is the continual recording of the harvested crop mass, operating width and forward speed as the harvester moves across the field. The yield is calculated from these recorded parameters. This data is commonly recorded on one-second intervals, but longer periods can be used. The basic relationship of a yield mapping system can be summarized by the equation

$$Yield = Mass / Area$$

where: *Mass* = mass of the harvested crop, and
Area = distance traveled x width of swath.

In order to use this relationship, several sensors must be incorporated into the system to record the data necessary to calculate yield. As the harvester moves across the field, yield values are calculated, displayed and stored by the system.

Other field attributes, such as weeds, lodged plants or varieties, can be recorded through operator inputs as the crop is being harvested. This type of information can be very useful later for interpreting yield maps and making management decisions.

YIELD MAPPING SYSTEM COMPONENTS:

Yield mapping systems can take several forms depending upon the crop being harvested and the manufacturer's design. To date, the most widely adopted yield mapping systems have been for grain combines. While other systems are available, they are less widely utilized. The information in this document is concentrated on grain yield mapping systems. However, many techniques discussed here are applicable to yield mapping systems for other crops.

A yield mapping system consists of several components. It must have sensors to calculate the amount of crop harvested over a given area of the field. A positioning system determines the location of the machine in the field as the crop is being harvested. The system must also include a data storage devise for recording the information, and an operator's console. ***Figure 1*** shows a schematic illustration of the yield mapping components. Most of the information flow in the system is from the sensors to the mapping computer. The operator console serves to both display data and to allow the operator to key in information and to choose options.

Yield sensors may measure either flow rate or weight. If a flow-rate system is used, the sensor is placed in the path of the harvested material so it can detect the flow rate of that material. For most popular grain harvesting systems, this is an impact sensor placed at the top of the clean grain elevator (***figure 2***). A weighing system may be used when a sensor cannot feasibly be placed in the path of product flow. In this case, the sensor would

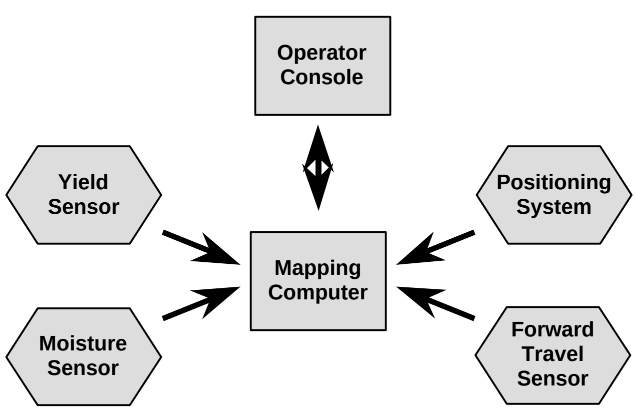

Figure 1 Major components of a yield mapping system

actually weigh the amount of the material being harvested. Regardless of the monitoring method used, the sensing system constantly measures the amount of a crop being harvested. A moisture sensor is also needed to determine the crop moisture status. When both the mass and moisture content are known, the yield can be calculated on a standard basis, eg: dry bushels. All this information is sent to the mapping computer, where it is stored.

The positioning system is responsible for recording the actual location of the machine as it moves across a field. The position and measured yield are recorded simultaneously, allowing the creation of yield image or map. Position information is provided by the Global Positioning System (GPS) augmented with a differential correction signal to improve the accuracy. The combined system is known as differential GPS or just DGPS. With a DGPS receiver, the position of the combine is recorded with a position accuracy of 4-6 feet. The DGPS receiver is mounted on the highest point of the harvester, normally either on top of the cab or the grain tank.

The data recorded is typically stored on solid state memory, often called "PC-Cards." These cards are small, portable devices that can be used to transfer the data from the harvester to an office computer. PC-cards are approximately the size of a credit card and can hold data up to several hundred hours of operation, depending upon the manufacturer. The data cards are placed into a slot on an electronic module, generally either the mapping computer (***figure 3***) or the operator's console. The mapping computer is responsible for receiving and recording the signals from the positioning system, the sensors, and the operator console.

The data recorded by the yield mapping system are calculated values. The mapping computer uses the grain flow measurement over a period of time to determine an actual mass of grain harvested. It then divides the mass of the grain by the harvested area. The harvested area is determined by multiplying the normal operating width of the machine

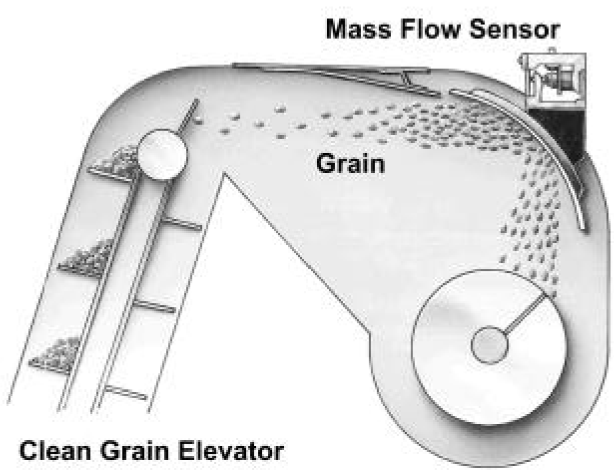

Figure 2 Mass flow sensor measuring grain. (Courtesy of Deere and Co.)

by its forward travel between data points. Forward travel can be measured by wheel rotation sensors, a radar unit, or from the DGPS signal. Depending upon the design of the particular yield mapping system, one or more of these options may be available. The most accurate form of measuring forward travel will depend upon each harvest situation. Wheel rotation is unable to detect any slip of the harvester's tires that may occur due to muddy conditions. As a result, the yields are often under estimated when using this method to determine forward travel. The accuracy of the radar measurement is determined by the correct calibration of the radar and by surface conditions. The accuracy of the DGPS forward movement calculations are primarily determined by the quality of the receiver used and the travel speed of the harvester. DGPS receivers may not be accurate for slow moving (<1.5 mph) machines.

The operator console (***figure 4***) displays information to the operator and allows the operator to have control of the system. The operator console must be programmed to contain information about the fields to be harvested. This information typically includes field names, type of crop harvested, and any other notes that are appropriate. The operator may also enter pertinent data while harvesting such as large weed patches diseased areas, or other field operations. During the actual harvesting, the operator console displays the current yield measured by the system. This display value is an instantaneous value obtained by the sensors. The value is shown in the units selected by the operator (English or metric). To calculate the area covered by the machine, the operator must enter the normal operating width of the harvester into the console. For corn harvesting, this is the number of rows being harvested; for small grains, the operator enters the width of the header.

Figure 3 Data card inserted into mapping computer. (Courtesy of Deere and Co.)

Figure 4 Operator's console mounted in the combine cab. (Courtesy of Deere and Co.)