Space Age Technologies Available for Site-Specific Land Management

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Foreword

New technologies are changing the way farmers and their advisers make decisions. Though many new technologies have not been fully evaluated, farmers are searching for guidance on how to them in their operations. Research activities currently are being conducted that test precision farming techniques in farmer fields. However, the conversion of scientific studies into knowledge takes time and requires a coordinated effort across many disciplines. Many questions have only begun to be answered, and many more questions will arise in the future.

Whatever your level of technology usage today, staying informed with changes occurring in production agriculture is invaluable. Not all new technologies offer clear and large economic benefits to all producers. However, being familiar with the technology will allow you to decide which pieces of the precision agriculture puzzle can be used to help you survive and thrive in a competitive world. Additional information on specific equipment is available at SDSU Precision Farming Web Page, Http://www.abs.sdstate.edu/abs/precisionfarm/index.htm

Some technologies that have been developed for site-specific land management include yield monitors and variable rate weed and nutrient application equipment.However, site-specific land management would not be possible with development of GPS or Global Positioning Systems.

What is GPS?

The Global Positioning System (GPS) (Figure 1) uses satellites to calculate and find the accurate position any where on the earth. GPS was initially funded by the Department of Defense (DoD) and is currently a joint project between DoD and orbit at an altitude of 10,900 nautical miles. These 24 GPS satellites are in predictable locations; hence, we refer to the system of satellites as the GPS constellation. In the past GPS information was partially scrambled by the Department of Defense. Scrambling increased the error of any given measurement. The Department of Defense has discontinued scrambling GPS signals.

Figure 1.A GPS receiver unit.

What can GPS be used for?

GPS can be used for almost any application that requires accurate positions and velocities. For example GPS can be used for hunting, ship navigation, ocean floor mapping, tidal measurements, aircraft navigation such as approach and landing as well as collision avoidance, aerial mapping, hiking, automobile user location and direction, remote sensing and fishing spot location. GPS has also made precision farming a reality. Position tracking with GPS receivers allows farmers and agricultural service providers to apply variable rates of inputs to smaller areas within larger fields.

What is the cost?

The accuracy attainable with GPS depends partly on how much you are willing to spend, ranging from approximately $100 to $100,000. A low-cost (from $100 to $500) GPS receiver without DGPS capability may be sufficiently accurate for some crop scouting applications, for navigating highways, or for locating your favorite fishing lake. In the past accuracy of this system was about 300 feet. However, because DoD has discontinued scrambling the signal, current errors may be less than 60 ft. The cost for a basic DGPS receiver suitable for most agricultural applications is about $3,000 to $5,000 and provides accuracy of at least 10 feet with a typical accuracy of 3 feet, which is sufficient for yield monitoring and grid soil sampling. If you need a GPS receiver for developing topographic maps the cost may be up to $25,000. Such systems provide accuracy down to a few inches.   Differential correction does not guarantee absolute accuracy because different receivers and sampling approaches have different accuracies. Differential corrections are available from a variety of sources including satellites and the Coast Guard. In South Dakota the Coast Guard differential correction is available from towers located in Whitney, NE, Omaha, NE, and Clark, SD. Generally a receiver must be within 150 miles of a tower to receive accurate differential correction. Error increases with distance from the tower.

More about GPS can be learned at these websites:

1. 1.“Global Positioning System Receivers ” by D. Pfost, W. Casady and K. Shannon.Document is available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=05279CA885256961005F1F2C15535763 .
2. 2.“Selecting a DGPS for Making Topography Maps” by D. P. Johansen, D. E. Clay, C. G. Carlson, K. W. Stange, S. A. Clay, and K. Dalsted.Document is available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=4AD0B0F385256966005F2D65A3804A59.
3. 3.“The Earth Model--Calculating Field Size and Distances between Points Using GPS Coordinates” by C. G. Carlson and D. E. Clay.Document is

available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=2188CA5885256965005ECE28994F9E43.

What Types of Equipment Use GPS?

GPS systems can be coupled to equipment such as yield monitors to collect crop harvest information or variable rate sprayers to apply pesticides or nutrients.

What is a Yield Monitor?

A yield monitor system is used to collect crop amounts when a combine harvests a field. The most widely used combine yield monitor consists of the following equipment:

1. 1.Impact plate or mass flow sensor to measure grain flow
2. 2.Moisture sensor to measure grain moisture
3. 3.Speed sensor
4. 4.Global Positioning System (GPS) receiver and antenna
5. 5.Console display microprocessor and PCMCIA card
6. 6.Software that is loaded on a desktop computer to create maps

Most yield monitors installed on combines use an impact plate and mass flow sensor located atop the clean grain elevator of the combine to estimate grain flow.As grain comes off the clean grain elevator and strikes the impact plate, a mass flow sensor develops an electronic signal that is proportional to the mass of grain hitting that surface (Figure 2).

Figure 2.A schematic diagram of the clean grain elevator, impact plate, mass flow sensor, moisture sensor location, and loading auger.

This signal, combined with a calibration equation and moisture content, is used to estimate instantaneous grain flow mass.The yield monitor is normally connected to a GPS receiver using a RS232 serial communications link.A second cable connects the GPS receiver to the GPS antenna that is usually located on the cab roof.The GPS receiver uses a standard message format, the NMEA 183 GPS-GGA message, to convey latitude and longitude coordinate information to the yield monitor.

The console microprocessor that receives the GPS latitude and longitude data, flow data; vehicle speed and moisture data is located in the cab. The monitor calculates the current yield and writes the data to a file on the PCMCIA card.The PCMCIA card can be removed from the yield monitor and inserted into a drive on a desktop computer to download the information.

Yield mapping software can access the yield data stored on the computer from the PCMCIA card and maps of the measured variables can be created.

More about GPS can be learned at these websites:

1. 1.“Yield Monitors—Basic Steps to Ensure System Accuracy and Performance” by J. Lems, D. E. Clay, D. Humburg, T. A. Doerge, S.

Christopherson, and C. L. Reese.Document is available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=4E42F3D2852569C4006C0399A8BB658B.

2. 2."Trouble-Shooting Yield Monitor Systems" by C.L.Reese, S.Christopherson, C.Fossey, J.Gray, A.Hager, R.Morman, G.Schmitt, B.Showalter, C.G.Carlson, and D.E.Clay.Document is available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=4B1CF8E1852569DC004D94B858901405.
3. 3."Yield Monitor Accuracy" by T. S. Colvin and S. Arslan.Document is available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=0454E0CA85256965005E1B99BDE10C51.

What is Variable Rate Equipment?

Variable rate pesticide sprayers have been developed by agricultural equipment vendors to minimize variation of applied rates of chemical within fields. The control systems compensate for changes in vehicle speeds and also provide the potential to change management inputs according to the severity of the problem.

Variable rate fertilizer applications have been developed and can be used to variably apply fertilizer to fields. Research shows that for the best results, the application equipment should drive slow (5 mph) and the positional location of the applicator should be updated every second as it drives over the field.

GPS systems can be used with variable rate equipment to apply the pesticide or fertilizer to a specific area of the field.An application map must first be developed.This is usually accomplished by measuring the soil nutrients or weeds present.The nutrient or weed data is collected with a GPS so that the exact position is known.This information can be entered into a special computer program to develop a map that will be used in the variable rate applicator.

Scouting fields with a GPS unit can take time especially if many acres need to be covered quickly.Another space age technology that may assist farmers with scouting their fields is remote sensing.

For further information about variable rate application equipment, see these websites:

1. 1."Variable Rate Equipment--Technology for Weed Control" by Dan Humberg.Document is available in Abode Acrobat format at: http://www.ppi-

far.org/ppiweb/ppibase.nsf/$webindex/article=A172CE4C8525696100631668C0F666E3.

2. 2.“Standardization and Precision Agriculture--'The Promised Land'” by Dan Humberg.Document is available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=16E24C5F852569650053078EB2D952D7

What is Remote Sensing?

One of the biggest problems in adopting space age technologies is obtaining timely, cost effective information, which can be used as a decision tool. Remote sensing may help fill this need.

The intention of site-specific management is to optimize grower inputs on areas much smaller than the entire field. Remote sensing can play a role in collecting data for site-specific management. Remote sensing is defined as the acquisition of information about an object without being in physical contact.

A simple example of remote sensing is when our eyes sense the reflected light from an object and our brain interprets the information. In this example, our eye is the detector and our brain is the computer that makes sense out of what was detected. The main focus of remote sensing in agriculture is the interaction of plants and soil with electromagnetic energy. Remote sensing sensors can be grouped into two main categories, photographic and non-photographic. Both provide information about electromagnetic energy and how it interacts with the surface being viewed.

Remotely sensed images have been used for crop identification, inventory of areas planted and estimation of potential harvest amounts. Remote sensing information has been used to detect field nutrient situations. Images from the green and near infrared bands highlight the amount of vegetation and give an indication of plant vigor. Hail and wind damage is a common occurrence in many parts of the U.S., especially in the Midwest and Plains areas. Information about the amount of damage is useful to crop management and accuracy of insurance payments.

Crop stress includes anything occurring in the field different than what was planned. The ratio of the red to blue to the near-IR scene reflectance can indicate plant stress before it becomes evident on the ground.Some of the common crop stresses that can be measured are drought, weed patches, soil erosion, nutrient deficiency and similar conditions. An example of drought stress is shown in Figure 3.The areas that are highlighted in yellow in the field are locations where lower elevations occurred in the field.The brighter red of the vegetation in these areas indicate that plants are healthier in these areas than other areas of the field.

The USDA Farm Services Agency (FSA) formerly the ASCS, has made use of aerial photography for many years as a means to verify compliance by landowners and farmers registered in the farm programs. Analysts at FSA use photography to measure the acreage of set-a-side or conservation reserve acres, determine locations of wetlands, verify conservation practices, and assist in disaster relief. This analysis would be very expensive to complete through typical ground visits. Additional information on remote sensing is available at

1. 1.“Remote Sensing: Photographic vs Non-photographic Systems by M. Schlemmer, J. Hatfield and D. Rundquist.Document is available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=9A1B7423852569660060DC03E933F405.
2. 2.“Interpreting Remote Sensing Data” by K. Dalsted and L. Queen.Document is available in Abode Acrobat format at: http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=D671F03A852569660064563B96971FC3.
3. 3.“Potential Applications of Remote Sensing” by C. J. Johannsen, P. G. Carter, D. K. Morris, B. Erickson, and K. Ross.Document is available in Abode Acrobat format at:http://www.ppi-far.org/ppiweb/ppibase.nsf/$webindex/article=AD4C296B852569660063220EFF05621E.

Additional information about how satellite imagery is being used by farmers and ranchers can be obtained at the UMAC website.UMAC stands for Upper Midwest Aerospace Consortium and is headquartered out of the University of North Dakota at Grand Forks, NS.UMAC’s website with remote sensing image information about farming and ranching is: http://www.umac.org/farming/.

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