Understanding Technical Terms and Acronyms Used in Precision Agriculture

Pedro Andrade-Sanchez and John T. Heun

Introduction

We live in a society that embraces technological innovation so easily because new technology can make our lives easier. In the last 30 years, our generation has experienced the explosive development of information technology, which is now a key element used at all levels of society and productive sectors of our economy. As expected, agricultural technology has also changed and is shifting to become an information-intensive endeavor. Regardless of the rate of change, traditional production systems will continue to evolve into modern, productive and innovative systems, and Cooperative Extension efforts will help facilitate this process.

Growers seeking to acquire new systems or upgrade existing equipment need to be fluent in terminology used in communications, hardware, software, and other areas in order to make informed decisions at the time of purchase. This information is needed to educate equipment operators in the use of information technology. Familiarity with key terminology is part of the training that workers need to maximize the use of expensive technology upgrades. This publication defines basic technical terms and acronyms used in describing the functionality and capabilities of precision agriculture technologies. The accompanying definitions were written in the context of modern agriculture. Note that these terms and acronyms are organized by categories and do not follow an alphabetical order, instead these terms are presented in a functional order for easy look-up and consultation.

Geospatial Mapping and Positioning Technologies

GIS – Geographical Information System. A computer system that records, measures, manages, or analyzes geographically referenced information or data.

Data layer (in GIS) – A layer of information on a GIS map. A map can have many layers to present different types of information. For example, the first layer of a map may be a satellite image of an area. The next layer may have only lines that represent roads or highways. The next layer may contain topographic information and so forth.

Satellite – A communications vehicle orbiting the Earth. Satellites typically provide a variety of information from weather data to television programming. Satellites send time-stamped signals to GPS receivers to determine the position on the Earth.

Geographic (spatial) data – Data that contains information about the spatial location (position) and the attribute being monitored such as yield, soil properties, plant variables, seed population, etc.

GPS – **G**lobal **P**ositioning **S**ystem. A system using satellite signals (radio-waves) to locate and track the position of a receiver/antenna on the Earth. GPS is a technology that originated in the U.S. It is currently maintained by the U.S. government and available to users worldwide free of charge. There are 30 satellites in the GPS constellation.

GLONASS – Russian version of the American GPS satellite system. It is a radio-based satellite navigation system operated for the Russian government by the Russian Space Forces with a constellation of 24 operational satellites in 2010.

GNSS – **G**lobal **N**avigation **S**atellite **S**ystem. Is the standard generic term for satellite navigation systems that provide geo-spatial positioning with global coverage using time signals transmitted from satellites. The United States GPS and the Russian GLONASS are the only two fully operational GNSS. Top of the line GNSS receivers can communicate with both GPS and GLONASS satellites effectively doubling the available reference satellites at any given time.

Beacon – Coast Guard Beacon tower system. A ground-based system to provide differential corrections primarily to the U.S. Coast Guard but also to civilians. Differential correction signals are broadcast to GPS receivers from radio towers and are affected by distance from the tower and topography.

SBAS – **S**atellite-**B**ased **A**ugmentation **S**ystem. These systems broadcast free correction signals from geo-stationary satellites to improve the accuracy, integrity and availability of the Global Positioning System (GPS) network, especially in areas where

the U.S Coastguard Beacon is not available. SBAS is a generic term that applies to both WAAS and EGNOS.

WAAS – **W**ide **A**rea **A**ugmentation **S**ystem. A combination of ground systems and geostationary satellites used to broadcast a differential corrections signal, compensating for GPS errors caused by atmospheric phenomenon. The corrections signals are broadcast from the stationary satellites as opposed to the Beacon system where correction signals are broadcast from radio towers and are affected by topography.

EGNOS – **E**uropean **G**eostationary **N**avigation **O**verlay **S**ervice. Is a satellite based augmentation system developed by the European Space Agency. EGNOS is the European equivalent to WAAS in the US.

DGPS – **D**ifferential **G**lobal **P**ositioning **S**ystem. This system operates using the same GPS satellites, with the addition of a differential corrections source (WAAS satellite or Coast Guard Beacon) to increase the accuracy of the system. In both cases, multiple ground stations provide the information about satellite error. Accuracy is typically better than 10 feet (3 meters) and can be better than 40 inches (1 meter).

CORS (network) **–** **C**ontinuously **O**perating **R**eference **S**tation. A network managed by the U.S. office of National Ocean Service (NOAA) to provide GNSS data consisting of carrier phase measurements throughout the United States**.**

RTK-GPS – **R**eal-**T**ime **K**inematics refers to a corrected position signal obtained through a complex procedure of carrier-phase measurements of the GPS or GLONASS signals, providing real-time corrections at the sub-inch accuracy level. The correction signal is provided by a RTK base-capable GPS receiver and the signal can be delivered to the vehicle (rover) in different ways. Depending on local availability, RTK corrections can be delivered by radio modem from an on-site base station or a state's CORS network, or even over the internet using Wi-Fi.

Base station – The RTK-GPS receiver and radio that are placed in a stationary position, functioning as the corrections source for roving tractor units in an area. These stations can be either portable or permanently installed systems and their coverage can range from 5 to 10 miles depending on topographic conditions, antenna height, and radio-transmit power.

NMEA messages – **N**ational **M**arine **E**lectronics **A**ssociation messages refer to a communications standard or specification originally designed to link GPS information with other types of marine vessel electronic devices. The information on position and speed come in the form of a specifically formatted data string from the GPS receiver and can be read by another electronic device that may make use of the information, such as an autopilot system. A typical NMEA string looks like this: $GPGGA,123519,3304.038,N,11159.935,E,1,08,0.9,545.4,M,46.9,M,,*47

GGA – GPS NMEA string containing data on time, position, elevation and the quality of the satellite signals. GGA strings contain GPS fix information.

VTG – GPS NMEA string containing data about velocity (speed and direction of travel) over the ground.

L1/L2 GPS signals – Refers to the radio frequencies used by GPS satellites. An antenna that can receive both L1 and L2 frequencies (in the MHz range) can communicate with older (L1) and newer satellites (L2).

Satellite weather (or visibility) **–** A term used to describe the number of available satellites in the field of view and geometry (or pattern in the sky), at any given time and location. Depending on the receiver/antenna, we can view GPS or the combination of GPS and GLONASS satellites.

Geographic Projection

Latitude – A global standard coordinate used to identify a position on earth given in degrees, minutes and seconds, indicates the north/south position above/below the equator, positive is in the northern hemisphere and negative is in the southern hemisphere.

Longitude – A global standard coordinate used to identify a position on earth given in degrees, minutes and seconds, indicates the east/west position around the globe from a reference point which overlays Greenwich, England. Negative values are east of Greenwich and positive values are west.

Geodetic datum – An important component in GPS systems to define where the receiver is on the earth. If using more than one GPS receiver, the user must take care to use the same datum on all GPS units.

UTM – **U**niversal **T**ransverse **M**ercator. A grid based coordinate system that breaks up the Earth's surface into zones in the Northern and Southern hemispheres. Because the Earth is a sphere, the distance between lines of longitude and latitude change across the surface of the globe. With the UTM system, the surface of the Earth is flattened and made to fit into a rectangular grid with constant values of distance between grid lines. The distance between grid lines is measured in meters, where latitude is replaced with Northing and longitude is replaced with Easting.

Coordinate projection – Refers to a coordinate system using a specific model of the Earth. UTM coordinates would be considered to be a coordinate projection as it uses a model of the Earth that is cylindrical. UTM's are projected onto a map based on latitude and longitude.

WGS-84 – A geodetic datum that defines the Earth's size, shape, and defines a reference point. The **W**orld **G**eodetic **S**ystem of 1984 (WGS-84) datum was created in the 1980's based on Geodetic Reference System (GRS) and satellite measurements.

NAD-83 – North American Datum of 1983 is a geodetic reference system similar to WGS-84, but NAD83 is an Earth-centered (i.e. geocentric) datum having no initial point or initial direction, and therefore defined to remain essentially constant over time for points on the North American tectonic plate.

Practicing Precision Agriculture

A-B line – The imaginary reference line set for each field that a tractor/sprayer guidance system to follow. There are different reference lines that can be set in a field to fit a particular geography or layout.

Accuracy (of GPS receivers) **–** The measure of closeness of an object's actual (true) position to the position obtained with a GPS receiver. Accuracy levels are used to rate the quality of GPS receivers.

Pass-to-pass accuracy – A measure of the relative accuracy of a GPS receiver over a 15 minute interval. This is typically thought of as "guess row error" when driving rows, or skip/overlap from one pass to the next when driving swaths.

Year-to-year accuracy – A standard measure of repeatability. In farming, it means returning to the same location in the field after a long time period has passed.

Precision – Refers to repeatability of multiple position measurements of the same object or condition.

DOP – Dilution **O**f **P**recision – Is a generic term used to describe fluctuations in the level of precision that GPS receiver can have in a short period of time. Several mathematical formulations exist to describe DOP, including: GDOP, HDOP, VDOP, PDOP, and TDOP which corresponds to Geometric, Horizontal, Vertical, Positional (3D), and Temporal Dilution Of Precision, respectively. Generally speaking, the lower the DOP value, the larger the number of satellites linked and therefore higher quality of GPS signal.

VRT – Variable-**R**ate **T**echnology – An electronic control system that changes or adjusts the rates of a chemical or material dispensed. VRT systems can be manually or automatically controlled to dispense material based on a prescription map generated from site-specific information.

Proximal sensing – Using sensors or instruments close to the object being measured, but not necessarily in contact with the object. Proximal sensing refers to the measurement of physical properties with electronic instrumentation, from a distance. The scale is much smaller than traditional remote sensing from satellites or aircraft.

Remote sensing – Using sensors or instruments (mainly referring to satellite sensor platforms) to measure aspects of the Earth, such as geographic features, from great distances. Satellite technology provides the means to measure and collect data on large scales, with frequency, and in extreme environments where conventional means of data collection is not practical.

Wavelength – In Precision Agriculture technology, wavelengths are referenced when talking about radio transmissions for wireless communication or devices that measure/emit light in different parts of the spectrum. In physics, the period of a wavelength is the distance between two wave crests (peak to peak distances).

NIR – Near-**I**nfrared – A portion of the electromagnetic spectrum representing light waves approaching infrared. Near-infrared light waves are on the far red end of the spectrum, some of which appear as extremely dark red or maroon and end at wavelengths that can't be seen by the human eye.

Real-time application – Using sensors to obtain information from a crop and applying materials at the same time. Real-time application commonly goes hand-in-hand with variable-rate systems. As differences in the crop are measured by a group of sensors, the variable-rate controller changes the amount of material/chemical dispensed in a given area. Information is made use of in 'real-time' as opposed to just collecting it and making use of it later.

Prescribed application – The dispensing of a material or chemical into the field on a prescribed or predetermined basis. A prescription map is generated by an expert (grower and/or agronomist) based on information about the field in use before an application. The prescription determines how much of something will be applied.

Variable-Rate Algorithm – – In the context of precision agriculture, an algorithm is a mathematical formula that is loaded into rate controllers to interpret sensor signals and control variable rate applications.

Zone management – The information-based division of large areas into smaller areas for site specific management applications.

Communication Technology

Modem – An electronic device used to transfer data or information from one device to another. Typically modems are used to transfer data over longer distances and usually transform information into a signal that can be sent over telephone lines. Other modems can use radio-waves as the carrier signal in a wireless system.

Spread-spectrum (in radio communications) **–** Transmission of data over a broad range of radio frequencies as opposed to a single carrier frequency. Data that is transmitted over a single carrier frequency (such as the case of AM or FM radio stations) can be easily disrupted or jammed by other signals that are close to or on the same frequency. When the data transmitted is 'spread' over many frequencies (determined by the volume of data), the likelihood of data loss due to interference becomes nearly zero. Spread-spectrum radios can even share frequencies with other radios without causing interference.

LAN – Local-**A**rea **N**etwork is a wired computer network that connects computers and devices in a limited geographical area such as home, school, or office building. LAN's are deployed in small geographic areas and have usually high data-transfer rates. LAN's allow access to the internet.

Wireless communication – Data transfer and voice communications using radio frequencies or infrared light (such as a TV remote control).

Wi-Fi – The term Wi-Fi suggests **Wi**reless **Fi**delity, and is used to describe a narrow range of connectivity technologies including wireless local area network (WLAN). Wi-Fi certified and compliant devices can be installed on personal computers and tractor-mounted displays.

Computer / Electronic Technology

Serial communication – Digital data that is passed from one device (a computer) to another in a serial fashion. In digital communication, information is sent in the form of 1s and 0s (binary). These 'bits' are pushed through the serial cable one at a time. Serial is one after another.

Baud rate – In serial communication, the baud rate (required for all devices joined) is set to establish the speed at which the 1s and 0s will be passed between devices. When baud rates do not match on two joined devices, the information gets lost or garbled. A device cannot 'catch' the 1s and 0s unless it knows exactly when to expect them.

USB – **U**niversal **S**erial **B**us. Is a specification to connect a computer with peripheral devices. In agriculture, the most common USB device is the flash-dive which is used to store data and transfer files to/from in-cab computer displays.

DB9 connector – Also called **D**sub**9** or D sub-miniature 9. It is a 9 pin connector shaped like the letter 'D'. They are used to connect serial devices together with a serial cable. They were commonly found on personal computers until the invention of the USB port. Adapters can be purchased to convert USB ports back to DB9 connections when necessary.

RS232 – A serial communications protocol defined by hardware and software. **RS** (**R**ecommended **S**tandard) 232 type connections (commonly used with DB9 connectors) are frequently used in connecting a single device to another. When a network of devices is used, it is more common to use RS485 or RS422 because these protocols allow for higher data transfer rates and communication between multiple devices on a single pair of wires.

Deutsch connector – Weather-proof connectors used for serial communication and DC power. The latching mechanism makes them exceptionally well suited for off-road equipment. The matching ends of Deutsch connectors are "receptacles" (with pins) and "plugs" (with sockets). These connectors come is arrays of 1, 2, 3, 4, 6, 8, and 12 wire leads. Color and letter codes define each type of Deutsch connector.

Firmware – The software embedded into a piece of electronic hardware. The firmware is what runs the microcomputers in a device and controls the electronic circuitry.

Prescription file – A computer generated GIS file that assigns a value to a given geographical area. Example: Nitrogen application rate.

Data file – An electronic data record collected during a field operation and typically saved in the storage card. Common delimiter-separated formats are comma-separated-value (.csv), .dat, and .txt.

Shape file – A GIS software file that can contain many pieces of information about a geographical area. There are 3 'pieces' of a shape file: .shp, .dbf, and .shx.

Unlock – Many devices come with additional functions and/or enhanced capabilities that need to be 'unlocked' before they can be used. Displays installed in tractor/sprayer cabs are good examples because they can use the free WAAS correction signals or unlock private correction signals such as RTK. Moreover, a display used for auto-pilot can be unlocked for other functions such as leveling and/or variable rate application. Unlocks are purchased though the equipment dealer.

Storage card – A memory device used to store data from an electronic device. The most common storage cards are Compact Flash (CF) cards, Secure Digital (SD) cards, and Flash Drives (Thumb Drive/USB Drive). These devices are commonly used in in-cab displays.

Precision Agriculture Equipment

Boom/section controller – An electronic device that is capable of turning on/off sections of a chemical application boom manually or automatically in combination with GPS positioning and area mapping.

Can-bus (in tractors and implements) **–** Can-Bus is a high-speed, wired data network connection between electronic devices. The hardware/wiring of Can-Bus networks are generally the same, while the protocols for communication can be different and vary depending on the industry where they are used. These networks are used to link multiple sensors to an electronic controller, which can be linked to relays or other devices on a single set of wires. This reduces the amount of wires needed for a system and allows for a cleaner way to connect additional devices as system demands change.

ISO-bus – Isobus standard 11783 is a communication protocol for the agricultural industry that is used to specify a serial data network for control and communications on forestry or agricultural tractors and implements. ISO-bus compliant tractors and implements come with round 9-pin connectors.

Electro-hydraulic valves – A hydraulic actuator (valve) that is opened and closed by an electromagnetic coil when a voltage is applied. On electronic controlled hydraulic systems, manually operated valves (levers) are replaced with electro-hydraulic valves which are operated with an applied voltage.

GPS antenna – The device that receives satellite signals from space. On most hand-held GPS devices, the antenna is integrated into the receiver device. For machine GPS systems, the antenna is typically an external device that can be mounted on top of the vehicle, away from the receiver.

On-board computer display – A computer screen that the operator uses to monitor and control machine related electronic systems.

Light-bar (in machine guidance) – A device connected to a GPS receiver typically consisting of a row of led lights to provide the tractor operator with a visual guide, day or night. The light bar does not automatically steer the tractor or machine, rather it aids the operator in driving on the imaginary reference line.

Rate controller – An electronic device that varies the amount of chemical/plant nutrient applied to a given area.

Receiver (in GPS hardware) – A computer-radio device that receives satellite information by way of radio waves to determine the position of its antenna relative to the earth's surface. The antenna can be integrated into the receiver or connected externally with a cable.

Autopilot – A system using corrected GPS signals to steer and guide a tractor/sprayer/spreader automatically through the field. A typical autopilot system would consist of one or two GPS receivers, a radio to receive corrections, a controller, a computer display, sensors, and electro-hydraulic valves or servo motor. Currently, most automated guidance systems only steer the tractor and the operator is required to control the throttle position, implement height, etc.

Steering assist – A system using corrected GPS signals, a steering motor, and a light-bar to guide the tractor operator through the field. Steering assist systems provide the operator with a visual guide and assist the driver by steering the tractor using an electric servo motor directly attached to the steering wheel.

Yield monitor – An electronic system that measures the amount of harvested product collected by production machinery.

Electronic sensor (optical, spectral, displacement) – A device consisting of electronic circuitry used to measure the physical world. Optical sensors use the physics of light to generate an electronic signal that can be used to measure physical characteristics. Spectral sensors refer to a line of electronic sensors that also use the physics of light to generate electronic signals but generally refer to sensing multi-bandwidths in the visible to infrared part of the electromagnetic spectrum. Displacement sensors refer to a line of sensors that use a reflected signal (sound/sonar, light/laser, radar/radio-waves) to find the distance between the sensor and an object.

Active/passive light sensors – Referring to sensors that measure light reflected from a target surface, such as plant leaves. Passive light sensors depend on sun light to function. They measure the magnitude of the light shining down from the sky, then measure the magnitude and colors of light being reflected from a surface to the instrument. Passive light sensors are affected by clouds and the angle of the sun in the sky. Active light sensors work the same way, but instead provide their own source of light to shine on an object. Sun angle and ambient light levels have no affect on these types of sensors. Active light sensors can even be used in the dark.

LED – **L**ight **E**mitting **D**iode. LED's can be designed to emit light from ultra-violet to infrared wavelengths.

Final Remarks

The definitions compiled in this publication provide a quick reference to technical terms and acronyms used in precision agriculture technology. These definitions are meant to be short descriptions for an initial understanding of their use and application in farm equipment. Readers looking for more detailed descriptions are encouraged to consult textbooks in precision agriculture such as: Precision Agriculture (by Brase), and Handbook of Precision Agriculture: Principles and Applications (edited by Srinivasan). In addition, other extension publications that include technical terms and acronyms in agriculture include the on-line listing by Shearer of the University of Kentucky (http://www.bae.uky.edu/precag/PrecisionAg/PAterms.htm); and bulletins from Rains and Thomas (2000); and Grisso et al. (2009).

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COLLEGE OF AGRICULTURE AND LIFE SCIENCES
TUCSON, ARIZONA 85721

PEDRO ANDRADE-SANCHEZ
Assistant Specialist, Agricultural-Biosystems Engineering, Maricopa Agriculture Center

JOHN T. HEUN
Research Specialist, Maricopa Agriculture Center

CONTACT:
PEDRO ANDRADE-SANCHEZ
pandrade@ag.arizona.edu

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