Advancing Golf Course Maintenance Equipment With Positioning Technology

GPS technology makes precision turf management a reality.

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With so many uses, the Global Positioning System (GPS) has become part of the everyday lexicon. Whether it is providing turn-by-turn directions to a golf course or an accurate yardage to a putting green from the fairway, GPS technology directly benefits golfers on a daily basis. Less obvious to golfers are the various ways GPS technology can be used to improve the efficiency and effectiveness of golf course maintenance.

GPS technology is the cornerstone of precision turf management — a site-specific management concept that optimizes the use of resources across various unique environments. The goal of precision turf management is to achieve the most efficient and effective delivery of inputs. As the accuracy of GPS improves, the concept of precision turf management becomes more powerful.

While precision turf management is not a new concept, full-scale adoption has, until recently, been limited by cost and complication. Historically, any GPS work on a golf course — e.g., mapping irrigation lines or calculating turf acreage — required the use of a contracted surveyor. As GPS technology has become more affordable, many golf courses are finding ways to apply it to daily maintenance operations. For example, GPS is making soil and turf sampling more powerful by providing an exact location from which each sample was collected. GPS technology also is improving the precision of equipment operation and spray applications. Still, golf is in the early stages of adopting GPS-guided equipment, particularly when compared to large-scale agriculture.

Table 1
Important Terminology

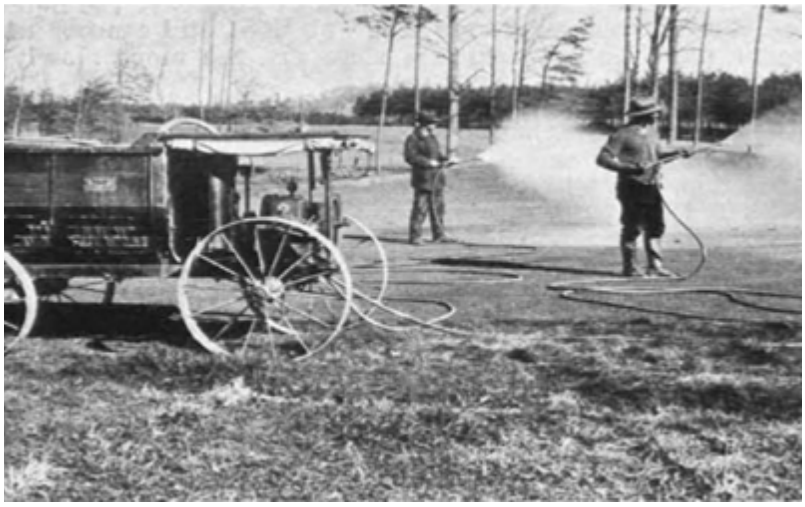
GPS	**G**lobal **P**ositioning **S**ystem – A global navigation satellite system controlled by the United States.
NAVSTAR	**N**avigation **S**atellite **T**iming **A**nd **R**anging – NAVSTAR GPS was developed by the U.S. Department of Defense. It was designed to use a constellation of at least 24 satellites positioned in six orbital planes.
GNSS	**G**lobal **N**avigation **S**atellite **S**ystem – Refers to a system of operational and planned satellites that provide global geospatial positioning. It is comprised of the NAVSTAR GPS (United States), GLONASS (Russia), Galileo (European Union), and Compass (China).
WAAS	**W**ide **A**rea **A**ugmentation **S**ystem – Method for improving GNSS accuracy to within 3 meters or better. WAAS uses a network of ground-based reference stations in North America and Hawaii. The reference stations correct variations in navigation satellite signals to improve location accuracy.
RTK	**R**eal **T**ime **K**inematic – Method for improving GNSS accuracy to within 1-3 centimeters by using a local ground-based reference station to provide real-time corrections to navigation satellite signals.
GIS	**G**eographic **I**nformation **S**ystem – Software program used to organize and analyze collected data on a map so that more informed management decisions can be made.

UNDERSTANDING GLOBAL POSITIONING TECHNOLOGY

GPS was originally developed by the United States Department of Defense for military applications. Eventually, GPS technology was made available for public use. Public access to GPS technology helped fuel the precision agriculture movement of the mid-1990s that resulted in greater yields with less waste thanks to GPS-guided equipment. Today, the golf industry is following suit with the release of GPS-enhanced equipment for maintenance.

As with any technology, a certain degree of confusion can arise with new applications for GPS. The confusion is understandable, especially considering the vast use of acronyms to discuss global positioning systems. Table 1 lists common global positioning terminology with which every turf manager should be familiar.

Simply put, GPS utilizes signals from a collection of satellites to triangulate the exact position of a receiver. The current system uses a minimum of 24 satellites operating in six orbital planes. GPS is one of only two fully



Golf course technology has come a long way. New equipment such as GPS-guided sprayers ensures maintenance tasks are completed in the safest and most efficient manner.

operational global navigation satellite systems (GNSS). Currently, the only other fully operational GNSS is called GLONASS, a Russian-developed system. Some GPS receivers are able to use both GPS and GLONASS satellites, adding a level of redundancy if a particular satellite is unavailable. Using both GPS and GLONASS also increases accuracy and location acquisition speed.

In order to pinpoint the location of a GPS receiver, data including latitude, longitude, altitude, and time must be collected from at least four satellites. Well-designed GPS receivers have the ability to provide horizontal accuracy of 3 meters — i.e., 9.8 feet — 95 percent of the time.[1] However, location accuracy is dramatically improved when a ground-based augmentation system is combined with orbiting satellites.

There are two augmentation methods commonly used by GPS receivers in the U.S. The first is the Wide Area Augmentation System (WAAS), which uses a collection of government-operated reference stations. WAAS stations are located throughout North America and Hawaii to identify positioning errors in satellite transmission data. The WAAS network of reference stations makes any necessary corrections to satellite-transmitted data before it is uploaded and eventually retransmitted from WAAS satellites to individual WAAS-enabled GPS receivers. Typically, WAAS-enabled GPS receivers are accurate to within 1.6 meters — i.e., 5.2 feet — 95 percent of the time.[2]

The second augmentation method, Real Time Kinematic (RTK) satellite navigation, provides even greater accuracy. RTK systems require a local reference station that can continuously communicate with a receiver to provide instantaneous corrections. The RTK base station directly communicates with a GPS unit via shortwave radio, delivering positioning accuracy to within less than 1 inch.

GPS PRODUCTS ON GOLF COURSES

There are a number of ways golf courses are leveraging GPS technology to maximize returns and reduce resource consumption. Applications for GPS technology include mapping, sampling, and even equipment-guidance systems.

MAPPING

The affordability of handheld GPS units has made in-house GPS mapping an option for many golf courses. GPS makes it easier to accurately document subsurface drain lines, irrigation lines, and important utilities. Also, areas can be measured using GPS technology and divided into management zones, helping fine-tune irrigation, fertilizer, and pesticide applications.

GPS data loggers — a type of GPS receiver that easily fits into a golfer's pocket — can be used as a resource management tool to identify exactly which areas of a golf course receive the most use. A GPS data logger tracks golfer movement during a round, revealing a plethora of useful information. The information generated by GPS data loggers can guide management decisions regarding the level of management and allocation of inputs in a given area. Matching resources with how often an area of the course comes into play is crucial to the economic viability of a golf course.

Mapping golfer movement also can identify pace-of-play issues. Understanding how players of different skill levels move through a golf course can pinpoint areas where adjustments to course design, maintenance, and setup could improve pace of play. The article "A Unique Approach to Managing Players and Maintenance" describes how GPS technology can be used to efficiently manage resources and improve the golf experience.

Additionally, golf courses are using GPS data loggers to improve operational efficiency. When handheld GPS data loggers are attached to golf course maintenance equipment, they track the movements and time required to complete maintenance operations. This can help ascertain the most efficient path to complete specific tasks, saving time and resources.

Combining GPS-generated data with a geographical information system (GIS) gives superintendents the ability to analyze relationships and patterns

throughout a golf course. GIS software allows the user to map and label natural and man-made features such as trees, bunkers, fairways, and underground pipe. Agronomic conditions, such as pest pressure, soil moisture, and pH levels, also can be accurately mapped. This information can be layered over a satellite image of the property to provide a comprehensive map of course features and conditions.

There are a variety of ways that GIS can be used to improve golf course management. For example, GIS can be used to accurately document the location of drainage and irrigation systems. Knowing the exact location of underground infrastructure will make future repair or replacement less frustrating and more cost effective. Golf courses also can use GPS to create a tree inventory that details the location, species, and health of each tree on the golf course. An accurate tree inventory can help managers understand where to focus tree-management efforts. Furthermore, having detailed maps of course features and infrastructure is valuable when developing maintenance budgets and prioritizing capital improvements.

SAMPLING

One of the most useful advances in turfgrass management over the past decade has been the adoption of portable soil moisture meters. Having instant access to precise and accurate volumetric water content values has helped golf courses conserve water, improve turfgrass health, and maintain better playing conditions. Soil moisture meters become an even more valuable tool when they are used in conjunction with GPS technology. The incorporation of GPS technology makes it possible to map moisture measurements, which can help superintendents detect trends and make site-specific adjustments to irrigation programming.

In addition to monitoring soil moisture, several golf courses are using GPS to track soil salinity and temperature. This information helps determine the most appropriate timing for management practices such as flushing salts or applying plant protectants. Combining data with accurate locations helps focus management efforts to create better, more consistent playing surfaces.

GUIDANCE

The golf industry is benefiting from the recent introduction of GPS guidance systems. Sprayers with RTK-enabled GPS guidance systems and individual nozzle control now are a reality, virtually eliminating inconsistencies by applying spray applications accurate to within 2 centimeters. GPS-guided sprayers improve spray results by preventing the overlaps and skips that occur even with the most experienced operators while ensuring products are accurately applied only to target areas. Also, GPS guidance reduces the time required to make spray applications because product is applied in the most efficient manner. Golf courses that use GPS-guided sprayer technology report saving 10 to 20 percent on chemical and fertilizer costs as a result of the improved accuracy.

GPS-guided sprayers also allow superintendents to generate a detailed report of how much product was

GPS-equipped sprayers include individual nozzle control solenoids (A) that automatically turn on and off, a display console (B) that shows application areas, and an antenna (C) that receives data from satellites.

GPS mapping allows turf managers to locate and describe golf course features. Identifiable features can include pest pressure, problematic soil conditions, trees, and underground utilities.

applied to specific areas of a golf course. These reports can be entered into a GIS program for further analysis. Trends and patterns can be identified that will improve pest control, growth regulation, and fertility management to create better playing surfaces and conserve resources. GPS-guided sprayers can be purchased or GPS guidance systems can be added to existing sprayers. Golf courses utilizing GPS-guided sprayers report a return on investment of only one to three years.

MOVING FORWARD

Observing trends in large-scale agriculture provides an idea of how golf course maintenance equipment will advance in the coming years. Large-scale agricultural operations rely on GPS guidance to automatically control tractors, sprayers, and combines. These state-of-the-art machines utilize GPS monitoring systems that report real-time engine data and control throttle levels for improved efficiency and reduced fuel consumption. Accurate GPS guidance systems also allow for consistency and repeatability. Technological advances in large-scale agriculture have already benefited the turfgrass industry and will continue to do so.

While we are still years away from commercially available GPS-guided mowers, there are autonomous mowing options currently available for the turf market. The RG3 mower from Cub Cadet® uses a local positioning technology that is not satellite based to autonomously mow. This robotic mower uses a series of beacons in fixed locations to triangulate its position and mow with incredible precision and accuracy. As satellite positioning technology becomes more affordable, similar autonomous products can be expected.

Another emerging use of GPS technology is guided, unmanned aerial vehicles (UAVs) used to survey crops with special imaging equipment that assesses plant health. Similar systems are being developed for turf managers. In fact, the USGA has been funding research to develop remote-sensing drought detection using UAVs. This technology can be expected to improve and become more widely used in the coming years.

New technologies can sometimes be confusing, but one thing is quite clear — future golf course equipment will use satellite-based positioning technology to improve operations and achieve precision turf management.

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