The Oklahoma Cooperative Extension Service

WE ARE OKLAHOMA

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and research-based information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

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Selecting the Proper GPS Guidance System for Your Operation

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Introduction

Computers and other electronics have become commonplace on most newer agricultural equipment. Producers can now collect more information about their operation easier than ever before. Most of this information is commonly tied to the location where it was collected. GPS coordinates are the most common way producers determine this location, so selecting the proper GPS system for the job is critical. Whether a producer has not used a GPS systems and wants to find an affordable entry level guidance system or wants to upgrade to the latest model with all the bells and whistles, there are many different things that should be considered when selecting a new system.

Accuracy

The accuracy of a GPS guidance system plays an important role in providing proper guidance to agricultural equipment. Many manufacturers list the rated accuracy of their system in the equipment specifications, but what does that mean, exactly? Most guidance systems are concerned with position accuracy, which is the difference between the measured position of the unit and the true position of the unit. Position accuracy can be measured in many different ways, but the three standard terms related to GPS guidance systems are absolute, pass-to-pass (relative) and repeatability (static).

Absolute accuracy is measured as the GPS receiver's ability to correctly identify a location on the earth's surface. If the absolute accuracy of a system is 1 inch, then the actual longitude/latitude coordinates of the GPS system will be within 1 inch of the longitude/latitude values calculated by the receiver. GPS guidance for agricultural equipment is usually concerned more about the relative accuracy between swaths than the exact location of these swaths.

Relative or pass-to-pass accuracy is measured as the GPS receiver's ability to return to a point measured no more than 15 minutes before. If the pass-to-pass accuracy of a system is 6 inches, then the GPS system should be able to return to within 6 inches of that point if no more than 15 minutes has passed since measuring the point originally. Pass-to-pass accuracy is the most commonly presented accuracy by equipment manufacturers because it is the most important for swath guidance. Figure 1 presents an example of an implement return pass using a 30-foot swath. Since the second pass is completed usually within 15 minutes of the first, the error should only be the pass-to-pass error (6 inches).

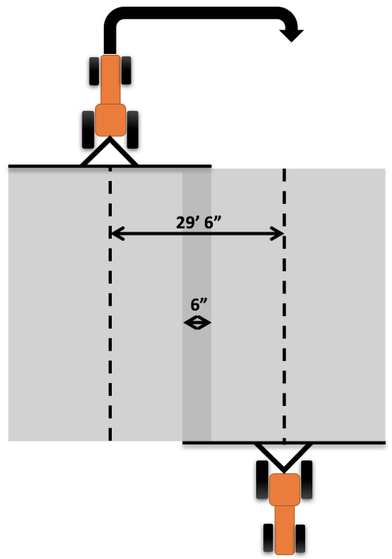

Figure 1. An example of pass-to-pass accuracy measurement for a standard 30-foot machine swath. Pass-to-pass error is 6 inches.

Repeatability or static accuracy is measured as the GPS receiver's ability to return back to a point measured more than 15 minutes ago. Typically, static accuracy is measured by collecting position data over a minimum of 24 hours. Repeatability is tied to the absolute accuracy of the system, changes in satellite configurations, atmospheric conditions, local interferences and other satellite data errors. Repeatability can be measured in terms of position error from month to month, year to year or longer. Figure 2 presents two separate passes using the same guidance line. The first swath may have been generated for a pesticide application, then a second application was made weeks or months later using the same guidance line. The difference between the two passes in the field (9 inches) is the static error. This may be the same or much higher than the pass-to-pass error. The type of receiver used determines these error values.

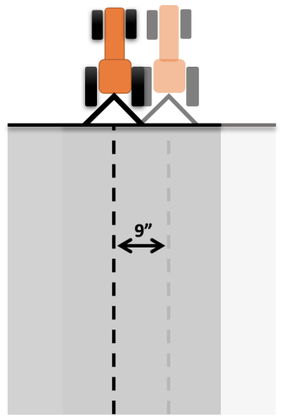

Figure 2. An example of repeatability for two passes over the same swath for two different field operations. The static error is 9 inches.

Type of Receiver

Standard GPS signals are a free broadcast to all users, but the accuracy of these signals alone is limited. The GPS signal must be combined with a correction or augmentation signal to improve the accuracy of the system to levels acceptable for guidance. The type of receiver used by the guidance system determines the type of correction or augmentation signal received by the system and how these signals are processed to improve accuracy. These correction signals can be divided into three general categories: public augmentation services, subscription augmentation services and real-time kinematic (RTK) systems. Table 1 lists some common field operations and the required correction signal type to achieve consistent results. Costs increase with position accuracy. It may be desired to select a correction signal that will meet the operational needs without going beyond what is required.

Public augmentation systems can provide a free correction service for GPS receivers within broadcast range. These systems can be ground-based towers such as the U.S. Nationwide Differential GPS network (NDGPS) maintained by the U.S. Coast Guard around ports and navigable waters or satellite-based augmentation systems (SBAS), such as the Wide Area Augmentation System (WAAS) maintained by the U.S. Federal Aviation Administration. Many newer receivers sold in the U.S. will use WAAS correction services due to the greater availability of the service and the phased reduction in the number of working NDGPS towers[1]. WAAS systems usually offer an average static accuracy of 36 inches with 6- to 8-inch pass-to-pass accuracy. Repeatability can widely vary, with drift being an issue.

Subscription augmentation services can use ground-based cellular towers or satellites to broadcast their correction signal. The type of accuracy that can be achieved by these systems varies from service to service. Many of the lower-cost options may not give much more pass-to-pass accuracy than the public augmentation systems, but increase the static

Table 1. Suggested GPS signal requirements by operation type.

Type of Operation	*WAAS*	*Subscription*	*RTK*
Spraying	✓	✓	✓
Spreading	✓	✓	✓
Drilling	✓	✓	✓
Air Seeding	✓	✓	✓
Tilling	✓	✓	✓
Harvesting		✓	✓
Planting		✓	✓
Cultivating		✓*	✓
Strip Tilling		✓*	✓
Banding/Side Dressing		✓*	✓
Controlled Traffic			✓
Bedding/Ridging			✓
Sub-Surface Drip Irrigation			✓

*dependent on service selected

accuracy to reduce in-season position drift. Subscription costs for these services can range from a couple hundred to a couple thousand dollars each year. There are several different services available such as Trimble RTX, OmniStar, Starfire, etc. Each agricultural equipment manufacturer will offer one or more of these services. Each service offers multiple pricing tiers ranging from a static accuracy of 1.2 to 20 inches with 1.2- to 6-inch pass-to-pass accuracy. Position data collected using these services are usually good for in-season use only or operations no further than 9 months apart.

Real-time kinematic (RTK) systems have an advantage in that they offer long term repeatability. Subscription augmentation systems have almost matched the static and relative accuracies of RTK systems for in-season operations, but cannot quite provide consistent repeatability from season to season. RTK systems do require a larger capital investment in the receiver and RTK radio. Correction signals are broadcast from a base station or stationary GPS receiver within 12 miles of the vehicle guidance system. A local base station can be setup along a field border or at a nearby building/tower. Many precision agricultural equipment dealers offer access to their own network of RTK base stations for a fee. There are many companies that offer similar base station network access through radio or cellular modem connections. Typically, RTK guidance systems can achieve pass-to-pass and absolute accuracies of 1 inch with long-term repeatability.

Many newer receivers will be capable of tracking more than one global navigations satellite system (GNSS). The U.S. NAVSTAR Global Positioning System (GPS) was the first GNSS completed and is used by every ag guidance system available for purchase in the U.S. The Russian GLONASS system is also used by some newer guidance systems in addition to the GPS system. The European Galileo and Chinese BeiDou systems will be operational in the near future. Many manufacturers are including support for multiple GNSS to increase the number of satellites in view at any point. Guidance systems that can track multiple GNSS will be more stable in areas where parts of the sky are obstructed by buildings or trees.

The type of receiver needed for your operation will depend on the intended use. Table 1 presents many common

field operations each type of receiver is capable of handling. Use this table as a guideline to select the minimum type of receiver technology needed when selecting a specific brand and model. When talking with the preferred precision agricultural equipment dealer, be sure to account for overall cost, features, ease of use, mobility and upgradability.

Cost

Price point is a major deciding factor for most producers who choose to invest in a GPS guidance system. Accuracy typically increases with increased product cost. Entry level systems, such as those that use WAAS correction, work well for many operations where the time between passes is minimal. Field operations that require higher accuracy will require higher capital investments in base station equipment, such as RTK systems, or require yearly subscriptions. Be sure to include any yearly subscription costs or fees in addition to the initial equipment costs. Often, subscriptions can be bought for the short-term, while the equipment is being heavily used, or piecewise by the feature. Many systems also have a strong used market and retain their value when upgrading to a newer device or purchasing a good used device. Be sure any used device requiring a subscription will allow the registration of a new owner.

Features

There are many different types of features found on agricultural GPS guidance systems. The number and type of features required is very producer and operation dependent. Most GPS guidance systems will have some type of indicator to denote position of the vehicle relative to the guidance line. Typically, this will be by a lightbar and/or LCD screen and the importance of either is operator preference.

The most basic guidance patterns found on entry level systems will be straight AB guidance lines. Other guidance lines include: A+, AB curve, adaptive curve, headland, center pivot, and smart. The availability and trade name of each will vary.

Many systems will have the ability to save and/or manipulate data collected during field operations. The ability to save field borders for future use, calculate area covered, etc. can be useful, especially when maintaining farm records. Some systems may have the ability to download this information into recordkeeping software or generate reports and maps directly.

Ease of Use

How easy the GPS guidance system is to use is an important factor when selecting a specific system. Consider how intuitive the menus, buttons and/or touch interfaces are for regular use. If there are multiple operators using the system, consider how easy it will be to train those operators. Many precision agricultural equipment dealers offer training and technical support for free or a fee.

Mobility

Typically, agricultural GPS guidance systems are installed two different ways: factory pre-wired and aftermarket. Factory wiring for GPS guidance systems is included on many newer agricultural vehicles and equipment. GPS guidance systems are connected into the factory wiring harness and typically use factory mounts for the display and antenna. These systems tend to be plug-and-play, when used with similar branded equipment. Many additional features may be available by integrating with the vehicle electronics such as vehicle diagnostic data, implement control or automatic steering.

Aftermarket systems typically use their own wiring harness that must be routed from the antenna to the receiver and typically use a 12V power socket adapter. Antenna and display mounts may be permanent or semi-permanent, such as magnets and suction cups.

When selecting which installation is appropriate for your operation, consider the intended use. Determine how easy the system is to set up on each vehicle and if one system can be easily moved from vehicle to vehicle or separate systems are required. Consider what happens to the system if the vehicle is in the shop for repairs or when the vehicle is sold/traded. The ease of moving the system between vehicles can be important for some operations versus a dedicated system for each vehicle.

Upgradability

When selecting a GPS guidance system, especially those with less features at initial purchase, consider the ability to upgrade the system as operational needs change. Many lower price point systems may have the ability to purchase additional software or hardware features to expand its capabilities. Add-on modules, such as automatic steering setups and rate controllers provide the ability to expand into other areas of precision agriculture beyond simple swath guidance. If interested in a system with the most flexibility, be sure to look for a system that can output NMEA sentences through an external communications port. These sentences or messages are the industry standard for GPS data that many third party electronics recognize.

Summary

There are many different things to consider when selecting a GPS guidance system for an operation. The type of field operation will determine the minimum receiver accuracy. When weighing the different options available through the various precision agriculture equipment companies, be sure to consider the true system cost, available features, ease of use, mobility of the system and the ability to upgrade the system as operational needs change.

References:

1. https://www.federalregister.gov/documents/2016/07/05/2016-15886/nationwide-differential-global-positioning-system-ndgps