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Precision Farming

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Precision Farming Tools- Light Bar Navigation

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GPS—Its Use and Potential Are Growing... Global Positional Systems (GPS) are widely available in the agricultural community. Farm uses include mapping yields (GPS + combine yield monitor), variable rate planting (GPS + variable rate planter drive), variable rate lime and fertilizer application (GPS + variable rate spreader drive), field mapping for records and insurance purposes (GPS + mapping software), and parallel swathing (GPS + navigation tool). For a review of the principles of GPS to locate specific field points, refer to the material presented at *www.trimble.com/gps/index.html*.

GPS and associated navigation systems are used in many types of agricultural operations. These systems are useful particularly in applying pesticides, lime, fertilizers, and tracking wide planters and drills. GPS navigation tools can replace foam and planter disk markers for making parallel swaths across a field. Navigation systems help operators reduce skips and overlaps, especially when using methods that rely on visual estimation of swath distance and/or counting rows. Also, a GPS navigation system can be used to keep implements in the same traffic pattern year-to-year (controlled traffic) and thus minimize adverse effects of implement traffic.

Use of GPS navigation in pesticide application with ground equipment has grown quickly. In the last five years, the use of GPS guidance has gone from almost nothing to being used by 29% (Medlin and Lowenberg-DeBoer, 2000) of fertilizer dealers who offer custom applications. Crop producers also are starting to use the systems because GPS navigation is an excellent way to improve accuracy, speed, and uniformity of application.

Foam Markers, a Widely Used Current Technology… Foam markers are the most common form of navigation aid used during fertilizer and pesticide application. The foam is dropped and used to align the applicator during the return pass. Foam markers utilize an air pump to pressurize a tank containing the foaming agent. The pressurized fluid causes the foaming agent to flow into an accumulating chamber. The foam collects in this chamber until the accumulated mass overcomes surface tension, causing a foam blob to fall to the ground. Most often the foam accumulators are placed at the ends of the applicator boom, or alternately at the center of the applicator when booms were not utilized, as in the case with spinner disk granular applicators. Equipment operators use the foam blobs left on the field surface as a navigation aid to know where the applicator has passed.

The Lightbar + GPS

In its most basic form, a lightbar system (Figure 1) consists of a horizontal series of Light Emitting Diodes, LED's, in a plastic case 12 to 18 inches long. This system is linked to a GPS receiver and a microprocessor. The term lightbar as used in the rest of this publication includes the GPS receiver and microprocessor. The lightbar is usually positioned in front of the operator, so he/she can see the accuracy indicator display without taking his/her eyes off the field. The lightbar can be mounted inside or outside of the cab and the operator watches the "bar of lights." If the light is on the centerline, the machine is on target. If a bar of light extends to the left, the machine is off the path to the left and needs to be corrected. If a bar of light extends to the right, the machine is off to the right. Software allows the operator to specify the sensitivity

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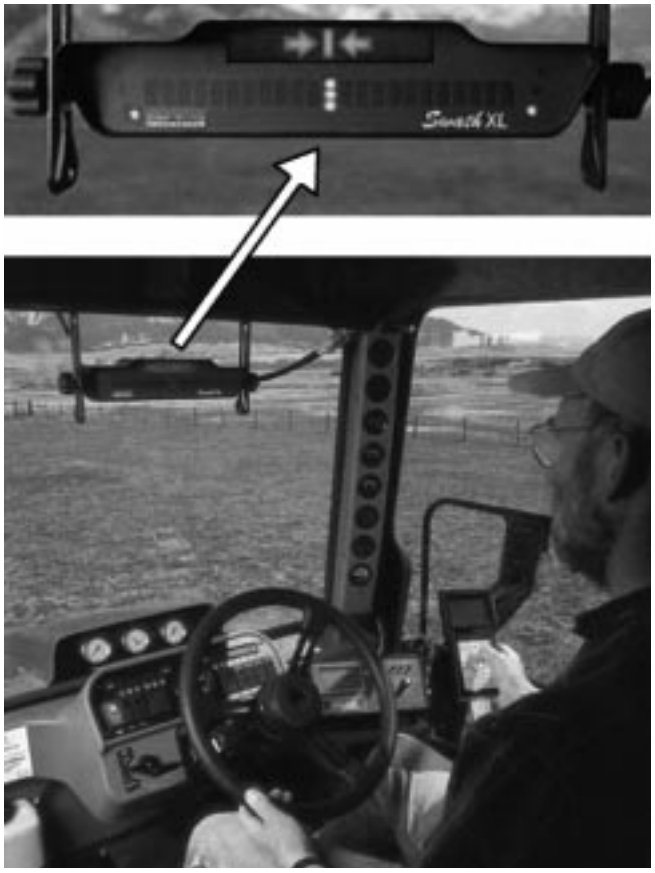

Figure 1. Lightbar navigation system mounted in cab and in view of forward travel.

and distance between the swaths. Similar GPS navigation systems have been used for aerial application since the early 1990's. Also, the GPS system gives the current location of the implement and with past traffic patterns the computer interface provides the operator directions to maintain proper swath width to match adjacent traffic paths. So if an operator leaves the field to refill the applicator or is forced out of the field due to weather, when the operator returns the applicator can resume and maintain accurate swath widths, and over-spraying on previous sprayed areas is eliminated.

More advanced systems have a screen showing the swath of the machine as it moves through the field. Early models only allowed straight-line parallel swaths, but current models are available for any contour traffic pattern. Areas covered with previous swaths are indicated on the screen. The advanced navigation system coupled with a variable rate spreader drive and software has the capacity to generate "as-applied" maps showing previous coverage and the application pattern. This provides an excellent record of the pattern and timing while operating in the field. Portions of the field that are not treated, such as wet areas, can be marked in the computer and stored for later operations when conditions permit application. All of this is done without having to physically mark the field area with flags.

Lightbar Navigation vs. Foam Markers

Potential advantages of Lightbar Navigation (LBN) for producers include:

- **LBN is more reliable and more accurate than foam markers-** Using foam markers could cause about 10 percent of the field to either be skipped or overlapped. With the lightbar, the skip and overlap rate drops to about five percent. Some tests have shown that with an experienced operator, the skip and overlap rate with the lightbar can be as low as 1.5 percent.

- **LBN allows accuracy at higher speeds-** With GPS guidance a 13-20 percent higher speed can be attained than with a foam marker (Buick and White, 1999)

- **LBN is a possibility with spinner spreaders** (Figure 2)**-** Foam markers are not generally used with spinner spreaders. The spreaders have no boom on which the foam equipment can be installed. Due to the spread width, a foam marker in the center of the machine path is difficult to see from the next swath, and the driver would still be using a visual estimate for the spreader swath.

Figure 2. Lightbar navigation system mounted in a spinner spreader.

- **LBN is easy to use-** Anybody can learn to use lightbar navigation systems regardless of computer skills. The systems are not difficult to learn with a little practice.

- **LBN provides effective guidance over growing crops-** With solid seeded crops, foam tends to fall through the canopy to the ground where it is almost invisible, contributing to skipping or overlapping. GPS is not affected by crop height.

- **LBN allows operation when visibility is poor-** LBN works at night, in dust or fog. This lengthens working time during critical planting and spraying periods. In many areas nighttime is best for spraying because of low wind speed.

- **LBN is less affected by weather-** In certain conditions such as, low humidity, heat, and large fields, foam markers can be rendered ineffective. The foam can evaporate before the operator makes the return swath. LBN works at any temperature, including low temperatures when foam systems freeze.

- **LBN has lower recurring costs-** LBN has no moving parts or tubes to clog. Depending on the manufacturer, software updates for LBN are usually free to system owners. Foam marker systems require foam, dye and tank cleaner.

The primary recurring cost for Light Navigator is satellite differential correction. Typically, this costs about $800 per year for each GPS unit. Many producers already have GPS for yield monitoring and pay a differential correction fee. For them, LBN has almost no recurring costs. In many areas of Virginia, it is possible to use the Coast Guard beacon or WAAS (Wide Area Augmentation System) for GPS differential correction. These services are free and may be adequate for some applications, including dry fertilizer with a spinner spreader. Accuracy for spraying should be within 6 inches (10 centimeters) so check with the GPS supplier regarding the differential correction needs for an individual area.

- **LBN reduces operator fatigue and eye strain-** With the lightbar mounted directly in front, LBN operators do not need to look backward or sideways. They can drive accurate swaths while looking straight ahead.

- **LBN has lower set-up time-** Foam markers have tanks to fill and dyes to change. LBN begins working approximately 30 seconds after the machine is switched on.

- **LBN is not affected by wind or boom bounce-** Blowing foam or a foam system bouncing at the end of a long boom over rough ground may introduce substantial error. GPS systems are not affected by rough land or wind.

- **LBN reduces pesticide use, by reducing overlaps-** If a 10 percent overlap is reduced to 5 percent, pesticide use also is reduced by 5 percent. Not only is this good for the environment, it's good for the bottom line.

- **LBN reduces need for people to enter already sprayed areas-** Allows the operator to mark where spraying stopped without dismounting.

Lightbar Navigation Cost

The most frequently mentioned disadvantage of LBN is the up-front cost. Costs range from about $3,000 for a farmer who already has a GPS to over $14,500 for a commercial applicator who might desire a system that keeps "as-applied" records as well as provides navigation.

A basic system with GPS and lightbar can be purchased for about $7,000. The biggest differences between the farmer and custom (private versus commercial) systems are speed, screen display, and the ability to provide a record of the applied area.

Foam marker system prices range from $900 to $2,800. Speed is also an issue in foam systems. The lower cost foam systems are slower and work adequately when application is done with a tractor. Commercial applicators operating at 20 mph need more foam output than lower cost systems can provide.

The useful life of the LBN units is hard to estimate because of the short period they have been available. Users should recover costs in three years. This short recovery time is due to the quick technology turn over and possibility of replacing these units with more accurate and cost effective equipment. Also, since these units have no proven track record for reliability, the shorter estimated life (3 years) gives a quick replacement life, if the unit fails under field conditions. Foam marker systems often last five years or more.

Cost and benefits vary widely depending on the crop, acreage covered, swathing accuracy achieved and other factors. Table 1 provides examples of LBN costs and benefits for two scenarios; a producer buying a complete system including GPS and lightbar, and a producer who already has a DGPS (Differentially Corrected GPS).

Both scenarios show LBN as increasing per acre costs, compared to the foam marker system. The cost per acre almost doubles for the producer who has an existing DGPS. For the producer starting from scratch, guidance costs increase by a factor of six. This means that from a producer's perspective, the justification of lightbar navigation is to determine the profitability of lightbar navigator over foam markers from the benefit side (lower part of Table 1).

The benefits estimated in Table 1 focus on only the opportunity cost of sprayer operation and the cost of extra pesticide and fertilizer at $10/acre. The estimated percentage overlap used is 10 percent with foam markers and 5 percent with lightbar navigation. For simplicity, the example assumes operators are very cautious and make only overlaps, no skips.

The machine cost of overlaps is estimated at $4.40 per acre for producers with tractor units. An estimate of $5 per acre should cover commercial applications. In most cases, the commercial application rate is a good estimate of labor and machine costs including depreciation, fuel, lubricant and repairs. Commercial rate is what the applicator would earn if the operator and machine were spraying another field instead of overlapping swaths.

The estimation of the economic impact of skips is complicated because the effect of crop yield varies by crop, i.e., for weed control, the weed population and how long term weed seed bank effects are valued, or for fertilizer and lime application, how much yield is lost if the area receives no application. A skip is much more costly in a higher value crop, such as vegetables, or seed crops, than it would be in bulk commodity such as corn, soybeans, and wheat. If the skip occurs in a very clean field, the yield loss effect due to reduced weed control may be minimal, but in a heavily infested field, the yield may drop to almost zero.

Table 1. Cost and benefit examples for Lightbar Navigator and foam marker use on a 1500-acre farm (Medlin and Lowenberg-DeBoer, 2000).

Item	Foam Marker	GPS & Lightbar	Lightbar Only[1]
Costs			
Purchase Price, $	$1000	$7000	$3000
Useful Life, yr	5	3	3
Annualized Cost, $/yr[2]	$300	$3033	$1300
Recurring Cost:			
Foam, $/yr[3]	$336	0	0
Differential Correction, $/yr	0	$800	0
Annual Cost, $/yr[4]	$636	$3833	$1300
Annual Cost, $/acre/yr[5]	$0.21	$1.28	$0.43
Benefits in Reducing Overlap:			
Percent of Area Overlapped	10%	5%	5%
Overlap Acres [5]	300	150	150
Machine Cost:			
$/acre[6]	$4.40	$4.40	$4.40
$/yr	$1320	$660	$660
Extra Pesticide and Fertilizer, $/yr[7]	$3000	$1500	$1500
Overlap Cost, $/yr	$4320	$2160	$2160
Overlap Cost, $/acre/yr[5]	$1.44	$0.72	$0.72
Lightbar net benefit, $/acre/yr		-$0.35	$0.50

[1] Assumes producer already has DGPS
[2] Annualized using a sinking fund approach with a 10% discount rate.
[3] Foam cost calculation assumed 0.007 gal./ac with the producer buying lower quality foam at $16/gal.
[4] Annual cost is the sum of annualized cost of investment and recurring cost.
[5] Acreage assumed is 3000 acres for the producer each year. The producer is assumed to cover the acreage twice with either a fertilizer spreader or sprayer (2x1500-acre farm size).
[6] Opportunity cost for sprayer operation assumes average rate for the producer at $4.40/ac.
[7] Extra pesticide and fertilizer assumes that the operators are very cautious and only overlaps occur with a pesticide or fertilizer cost of $10/ac.

Weed scientists suggest that the greatest economic effect of skips may be the creation of a seed bank that will lead to management problems in future years. Similarly, for a field at pH 5.8, the yield loss due to skipping an area with lime will probably be little during the first year, but will become greater in later years.

The values in Table 1 are a conservative estimate of LBN benefits, which does not include many of the advantages outlined above. In this example, the producer who does not own a GPS would need about 2,000 acres to break even. The analysis also shows that the break-even acreage for the lightbar is only 600 acres for producers with DGPS.

Bottom Line

Lightbar Navigation has many advantages over the conventional marking devices such as a foam marker, and especially over the visual estimation method for spinner spreaders. With an existing GPS that is being used for yield monitoring or field mapping and soil sampling, the lightbar navigation system can increase the efficiency of the farm or agribusiness while minimizing adverse environmental impacts associated with overlapping applications. Also, the system can reduce operator fatigue and anxiety regarding fertilizer and pesticide application. Finally, use of this technology can demonstrate to the non-agriculture community that advanced technology is being used to farm efficiently and safely.

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