AUTOMATION OF A WIRELESS COTTON MODULE TRACKING SYSTEM FOR COTTON FIBER QUALITY MAPPING

A Thesis

by

ANDREW J. SJOLANDER

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2009

Major Subject: Biological & Agricultural Engineering

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Approved by:

Co-Chairs of Committee,	J. Alex Thomasson
	Ruixiu Sui
Committee Member,	Cristine Morgan
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ABSTRACT

Automation of a Wireless Cotton Module Tracking System

for Cotton Fiber Quality Mapping. (August 2009)

Andrew J. Sjolander, B.S. Texas A&M University

Co-Chairs of Advisory Committee: Dr. J. Alex Thomasson
Dr. Ruixiu Sui

The ability to map the profit made across a cotton field would enable producers to see in detail where money is being made or lost on their farms. This ability, which requires site-specific knowledge of yield, fiber quality, and input costs would further enable them to implement precise field management practices to ensure that they receive the highest return possible on each portion of a field and do not waste materials and other inputs throughout the field. Investigators at Texas A&M previously developed a wireless-GPS system that tracks where a module of cotton comes from within a field. This system is a necessary component in mapping fiber quality, which is a major determiner of price and thus profit. Three drawbacks to the previous wireless-GPS system are that (1) a person must manually trigger the system to send wireless communications when a field machine dumps its load of cotton, (2) multiple field machines of the same type (e.g., two cotton pickers) cannot be used simultaneously on the same system within the same field, and (3) no software is available to automatically produce fiber-quality maps after the data are downloaded from the gin. The first two drawbacks, the need for an automatic communication-triggering system and the needed capability for multiple field machines of the same type are the problems addressed in this work. To solve the first problem, a sensing and control system was added to a harvester to automatically indicate when the machine is dumping a basket load of cotton so that wireless messages can be automatically sent from the harvester to subsequent field machines without human intervention. This automated communication-triggering system was incorporated into the existing wireless-GPS system, rigorously field tested, and ultimately proven to operate as designed. Linking data collected with this system together with classing information will enable producers to create fiber-quality maps, and linking fiber-quality maps with yield and input-cost maps will enable them to create profit maps. Additionally, a radio-frequency identification (RFID) system was integrated with the wireless-GPS system to allow for multiple field machines of the same type. The RFID system was also rigorously field tested and proven to operate as designed. Finally, the entire system was field tested as a whole and operated according to design. Thus, the wireless-GPS module tracking system now operates without human intervention and works with multiple field machines of each type, two additional capabilities required for practical use in large farming operations.

ACKNOWLEDGEMENTS

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INTRODUCTION

With rising fuel and material costs, one way agricultural producers can improve profitability is by implementing precision-agriculture practices. To do this, detailed records must be kept of the spatial and temporal variability of various aspects of production. An initial step in this process is to create a yield map of the field or area in question. For cotton production this capability has been realized with the creation of onboard yield monitoring systems (Wilkerson et al., 2001; Thomasson and Sui, 2003). If fiber quality information is available, having yield maps can enable revenue maps to be generated for the producer and help to determine which parts of fields require higher or lower levels of agricultural inputs.

Profit mapping, which can be done by comparing a revenue map to an input cost map, would allow cotton producers to see specific areas within their fields that are returning the highest profits. An example of a profit map with module-level map units is shown below, with the red areas representing profits and the green areas representing losses.

This thesis follows the style and format of the journal *Transactions of the American Society of Agricultural and Biological Engineers.*

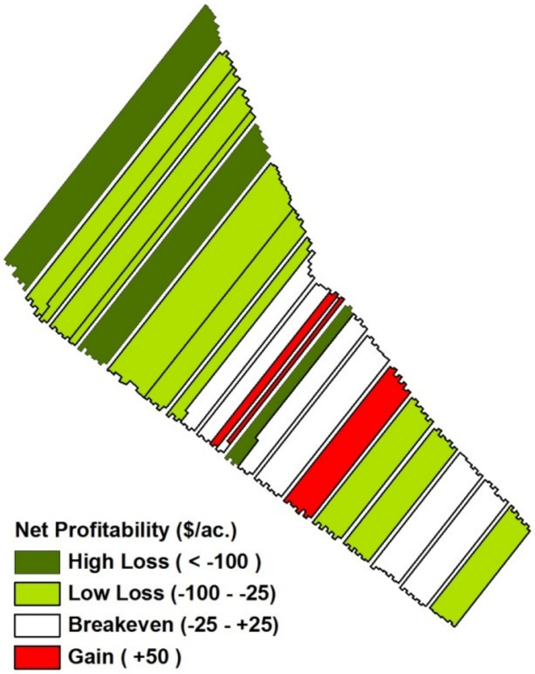


Figure 1. Example profit map. (Ge, 2007)

Precisely accurate profit maps, however, would require detailed spatially variable fiber-quality data. Practical fiber-quality maps have not been available previously due to producers' inability to track the original locations of cotton bales and to map the quality of these bales back to the field. With the creation of a wireless cotton module tracking system (Ge et al., 2006; Ge, 2007), producers now have the fundamental capability to accurately determine from where specific modules of cotton originate. The system is only accurate down to the cotton module level, since a single module will produce multiple bales, and the location of each bale is undeterminable in the present harvesting system. Therefore, the bales that are created from one module must have their fiber quality characteristics averaged together so that a single value for each fiber quality characteristic exists for a given module. This concept is known as module averaging, and USDA-AMS Cotton Division has already made it available to cotton producers since 1991. Module averaging is viewed by some to be a more accurate representation of cotton fiber quality than individual bale data. With the wireless cotton module tracking system, module averages of fiber quality data can be mapped to their original locations on the producer's field. Once these maps, along with maps of yield and cost, have been produced for a given field, an accurate module-level profit map can be created.

Ge's (2007) module tracking system uses three subsystems to follow cotton as it is transferred from vehicle to vehicle within the field. The subsystems are installed on the harvester (HSS), the boll buggy (BBSS), and the module builder (MBSS). Integrated into the HSS is a GPS unit that records location information while the harvester moves throughout the field. This GPS information is stored along with a harvester basket identification number so the harvest locations of the basket of cotton can be known. When this cotton is transferred the harvester operator presses a button for the desired transfer location, either a boll buggy or a module builder. If the cotton is being transferred to a boll buggy, the HSS sends wirelessly to the BBSS a message which includes the basket ID number. This ID number is then held by the BBSS until the boll buggy transfers the cotton to the module builder. When the cotton is transferred to the module builder, the BBSS relays to the MBSS the wireless message from the harvester with the basket ID. Upon receiving this message, the MBSS automatically sends to the HSS a wireless message which has a module ID number. Within the HSS this module ID number is paired to the corresponding harvester basket ID. In the event that the harvester transfers cotton directly to the module builder, the HSS sends the basket ID message to the MBSS, which automatically sends the module ID message back to the HSS.

Though the current module tracking system of Ge (2007) is accurate and effective, there remain three significant shortcomings with the design. First, users must interact with the system, informing it when a harvester or boll buggy is dumping a basket of cotton. This interaction causes the attention of the operator to be drawn from the task at hand and results in reduced reliability, efficiency and safety. Second, the system is not capable of accepting multiple machines of the same type such as more than one harvester. On large farming operations producers often use multiple harvesters, boll buggies, and module builders in the same large field. Third, data produced by this system must be downloaded onto a computer, entered into a GIS, and the GPS data linked with the fiber quality data. Often this process is time-consuming and complicated and therefore not practical for a cotton producer.

First, the need for complete automation of the system's field operation is the most important issue in making it practical. Automation would remove the need for operators to watch the harvest specifically for machine dumps in order to initiate wireless transfer of data with the system. To automate this process, a sensor (or sensors) and associated software are necessary to automatically trigger the wireless system to transmit a tracking message whenever a basket is in the dump position and cotton is leaving the basket. Some peculiar issues must be addressed with automation of this system. An example is when a harvester's or boll buggy's basket may be dumped partially and then set back down with cotton remaining in the basket. The potential for instances such as these is significant;

therefore, the basket's position alone cannot be used to determine whether or not the machine is dumping.

Second, the ability for the system to accept multiple machines of the same type is another crucial improvement. As can be seen in Figure 2, by simply having two harvesters, two boll buggies, and two module builders many different dump scenarios are possible.

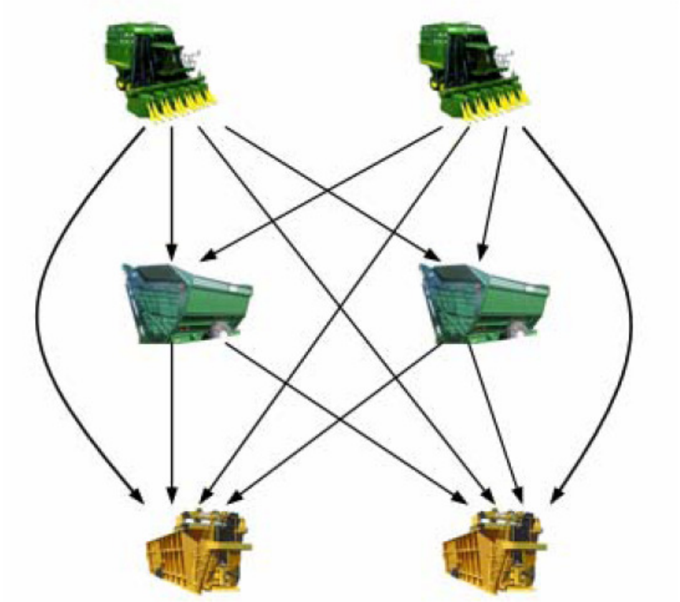


Figure 2. Dump scenarios with two harvesters, boll buggies, and module builders. (Ge, 2007)

To accurately track cotton's location from within a field, the specific harvesting machines involved in a single cotton transfer need to be known. In the current system the harvesting machine that is dumping merely sends out a wireless signal to any harvesting machine that is receiving within roughly a one-mile radius. If there were two module builders within that distance, then each module-builder subsystem would think that it had received cotton from the transmitting harvester or boll buggy, and both module-builder subsystems would then try to assign a module number, with one being incorrect and redundant – under normal circumstances, there should only be one module number per basket of cotton. Further software development and use of sensors will be required for the system to determine which harvesting machines are involved in a specific cotton transfer.

Finally, as previously mentioned, the system has a third issue with practical applicability. Producing the maps essential to use the system for precision agriculture requires advanced software that is difficult for the lay person to use. By automating the data downloading process and the production of maps, producers would only need to initiate mapping, and then the software would handle downloading the data and producing the maps. Automatic map production can be added by software development.

OBJECTIVES

The most important improvements involve field operation of the system, so the objectives of this research are twofold: (1) to make the system capable of automated wireless message triggering, and (2) to make the system compatible with multiple instances of similar machinery (i.e., more than one harvester, boll buggy, and/or module builder) in a given field. Automated mapping will be considered at a later date.

LITERATURE REVIEW

In order to automate wireless message triggering on the wireless module tracking system (WMTS), a sensor or set of sensors must be selected to determine when a harvester or boll buggy is dumping. Therefore, related literature concerning the sensing of component position and load are reviewed forthwith. Additionally, in order to make the system capable of working with multiple similar machines, some mechanism must be used to enable the machine that is dumping to recognize the receiving machine. Therefore, literature discussing the recognition of one machine by another machine is included.

Position Sensing

A remotely operated vehicle (ROV) positioning system that uses an ultrasonic pinger was developed by Han et al. (1994) for use in underwater exploration. After the pinger sent out a signal, the heading of the ROV was determined by use of a directional transducer, and the distance was determined by the amplitude of the received pulse. The pinger was attached to the ROV while the transducer was onboard a following boat. Use of an ultrasonic pinger allowed the position of the ROV to be accurately tracked and therefore graphed over a given time. This system had to be refined, since the initial position values were unreliable due to the effects of ocean currents and objects on the signal sent from the pinger. Han et al. corrected these errors by synchronizing the pinger and the transducer, allowing the time difference between transmission and reception to determine the distance between the two objects. Integrating this type of system into a cotton harvester could make tracking basket position possible. By placing an ultrasonic pinger on the harvester underneath the basket, the distance between the ultrasonic pinger and the bottom of the basket could be determined. This distance could then be translated into an assessment of whether the harvester's basket is in the dumping position. Also, a sensor such as this could be used to establish the position of one machine with respect to surrounding machines. For example, by positioning the pinger on the boll buggy, the transmitted signal would be reflected back by equipment close to the boll buggy. The pinger would only need to be mounted on the boll buggy since it would travel close to both the harvester and the module builder. The amplitude of the signal returned from the surrounding equipment would vary, with closer equipment returning a larger amplitude value than that of farther equipment. After the closest machine to the boll buggy were identified, communication could be established between the machine subsystems and then data transfer could occur. In the instance that the harvester was to transfer cotton directly to the module builder, however, the pinger system on board the boll buggy would not work. To account for this possibility, the harvester would also need to have a pinger, which would require the pingers to be set at different frequencies. In the event that a producer were using two harvesters, two boll buggies, and two module builders, four pingers would be required, all at different frequencies. Introducing more harvesting equipment into the picture requires more frequencies to be used, increasing the possibility that surrounding devices would interfere with the system.

Another position sensing system, for use on an automated tractor in a mulberry field in Japan, was designed with the hope of increasing production of silk from the mulberry silk worm (*Bombyx mori*). The initial system, designed by Kobayashi (1992), used a bumper to detect when an object was in the pathway of the machine and therefore required the machine to turn slightly. This contact-type sensor is possibly the simplest sensor that could be applied to a cotton harvester basket. Because the sensor could be set up on a normally closed or normally open circuit (i.e., signal is generated only when the bumper is released or contacted), multiple sensors could be positioned at various locations on the harvester basket. When the basket would begin to rise, a change in the state of a sensor could signal that cotton was being unloaded, and the required actions could then be taken. Kobayashi also refined his design, later using non-contact type ultrasonic sensors similar to the pinger system used by Han et al. The ultrasonic sensors sent out a signal ahead of and to the side of the machine to indicate the position of the crop to be harvested. This signal determined the distance between objects and the machine and then determined what course of action the machine should take. It is conceivable to use either the ping-type sensor or a contact sensor for detecting harvester-basket dumps.

The extension of the hydraulic cylinders used for lifting the harvester's basket or opening the basket door is another indication that unloading is taking place. Henke (1988) developed a system that uses the interaction between magnetic fields from a variably charged wire and a magnet to determine the linear distance between two points on a hydraulic cylinder. The system requires the wire to be threaded through a tube made of magnetostrictive material, which in the case of a hydraulic cylinder would be the extending rod. Having the extending rod made of a magnetostrictive material allows it to change its shape or experience strain when a magnetic field is present. A current would pulse through the wire creating a magnetic field inside the length of the magnetic tube. When the tube was passed through a doughnut-shaped magnet, the magnetic field produced by the wire would interact with the doughnut-shaped magnet's field at a particular location where a local strain would be produced. The resulting strain would take place for the duration of the pulse through the wire. By determining the amount of time taken for the pulse to reach the end of the tube, the distance between a reference point and the external magnet can be calculated. The cylinder rod on the cotton harvester basket could be configured in such a way with a wire and magnet. Using the hydraulic cylinders to determine the basket's position could possibly eliminate much of the error or signal noise that is present in the other systems. While the hydraulic cylinders would experience some movement during normal operation, since they would not normally fully extend, no signal would be sent to indicate that a dump was in progress. Incorporating this idea onto the hydraulic cylinders that lift a cotton harvester basket would require significant modifications. Aside from the difficulty in installation, such a system would require a substantial amount of space immediately surrounding the hydraulic cylinders, which is typically not present on cotton harvesters.

Doebelin (1990) discussed many available types of sensors that could potentially be used within the module tracking system. For example, pendulous or gravity-referenced position sensors are another viable option for use in this application. This type of sensor would be able to signal when the basket is moved from its original horizontal position. An enclosed small weight inside the sensor is acted upon by gravity, and the difference from the weight's original position is determined by the force applied to various springs connected to the weight. The simple design and the inexpensiveness of these sensors make them attractive, but they are sensitive to horizontal accelerations that can make them less accurate. However, a sensor like this could be mounted on the back of a cotton harvester's basket, and these effects would thus be minimized. Also, a Hall Effect sensor produces a voltage when it detects a change in magnetic field, typically caused by the change in position of a magnet nearby. If a Hall Effect sensor were applied to a moveable object on a cotton harvester's basket, such as a basket support arm, the sensor could determine when another object, such as the edge of the basket with an attached magnet, passed over that location. Hall Effect sensors are very good at determining small distances, but such high precision could present problems due to the vibrations of the cotton picker in the field. However, the signal noise caused by vibrations could be corrected with electronic filtering. Optical sensors were not strongly considered due to the high probability that cotton lint would cling to surfaces and cover the sensor.

Load Sensing

Attaching load cells underneath the harvester's basket was also considered, mainly as a possible indication of how much cotton remains in the basket after a dump. Hall et al. (1997) incorporated three bending-beam load cells on a Carter brand flail forage harvester – a machine usually equipped with a single load cell, if at all – to determine the amount of material within its collection basket. When one load cell is used, as the harvester stops after harvesting a plot, the amount of time required for the basket to stabilize is often excessive. Additionally, windy conditions can cause the collection basket to pitch and sway and forage to be thrown past the basket and therefore not be collected. If such a sensor system were applied to a cotton harvester, it is not expected that any cotton would be thrown past the basket and lost, but basket movement could be a problem with signal stability. To help alleviate movement in the forage harvester's basket, two additional load cells were added underneath the basket. The load cells were set up in a triangular formation, with one load cell at the front of the basket and the other two at the rear corners of the basket. All of the load cell values were combined to come up with an overall value for the total yield of each plot. The triangular support configuration stabilized the basket significantly during strong wind gusts and when the harvester drove over rough terrain. By reducing the amount of time spent at the end of the field waiting for the load cell signal to stabilize and by reducing how far the basket could pitch and sway in the wind, the amount of forage gathered increased with the implementation of the new design. More forage could be harvested since the harvester could spend more time in the field and, without the basket moving as much, more forage could be collected in the basket.

Peanut harvesters are not typically equipped with yield monitoring systems. A design was created by Thomas et al. (1999) that incorporated load cells into a peanut harvester, ultimately to determine the yield of the field. A frame was developed and placed directly under the collection basket, to which four double-shear-beam load cells, each capable of measuring up to 2268-kg (5000-lbs), were attached in the corners. The researchers tried three different configurations for the load cells: 90º, 45º, and in-line (Figure 3). Of the three load cell configurations, 90° worked best for reducing the chance of the load cells' binding when the basket was dumped. As the basket was raised to unload the peanuts, the load cells near the front of the harvester went from undergoing compression to undergoing tension. This occurrence happened as the basket tilted to unload its cargo, and when the basket tilted higher the weight moved towards the rear of the harvester, thus pulling up on the front of the basket's frame. These forces created by raising or lowering the basket may be present on cotton harvesters as well and need to be accounted for when considering where to place load cells. During a test conducted with the peanut yield monitoring system, the slope of the terrain was found to significantly affect the weight experienced by the load cells. A concrete anvil weighing 316 kg (697 lbs) was suspended by the four load cells with the frame tilted at 0°, 5°, and 10°. The 45° load-cell configuration was the least accurate in this test with a difference of about 2.0 kg (4.4 lbs) from the actual weight at all the incline angles. The in-line and 90° configurations yielded similar results, both having approximately a 1.4 kg (3.1 lbs) difference between the actual and measured weights. All the configurations measured the weight fairly accurately; the 45° configuration had the greatest percent error at 0.6%.

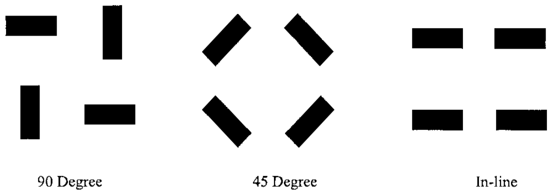


Figure 3. Basket load cell configurations tested. (Thomas et al., 1999)

Recognition of Individual Machines

Radio-frequency identification (RFID) systems, which send and receive information between objects, are becoming more and more present in agriculture. RFID technology uses two devices to transfer data wirelessly, a reader (which includes an antenna) and a tag. The reader scans its surroundings for tags by sending out a signal, when initiated by a user or automated system. Every reader sends out this signal at a specific frequency that can only be detected by other devices set to this frequency. All RFID tags within the reader's range that are set to the same frequency are activated by the signal and send out the data that they have stored. Bekkali and Matsumoto (2007) discussed using RFID to determine the location of robots in a given area. They created a tracking algorithm that calculated the distance, and therefore position, of the robots relative to stationary RFID antennas. Cotton module builders could be set up as the RFID antenna locations since they are often stationary, and RFID tags would then be attached to the harvesters and boll buggies. Having multiple antenna locations would maximize the coverage area for detecting the RFID tags; however, a complicated algorithm would need to be created to differentiate among the various RFID signals. If RFID readers were installed on the harvester and boll buggy, a reader would not need to be able to detect RFID tags that were farther away than 6.1 m (20 ft), since reading would be required only during dumping and the machines involved in a dump must be within that distance of each other. An RFID reader would be required on both the harvester and the boll buggy, because either vehicle could dump into a module builder. Using two (or more) RFID readers that move throughout the field would allow a simpler algorithm to be used to determine the closest cotton vehicle during dumping, and thus the receiving vehicle. Also, the readers' antennas can be oriented so that they scan only on the side where a cotton receiving vehicle would be positioned.

Another potential method for determining the location of harvesting equipment utilizes global positioning system (GPS) receivers. Single-frequency GPS receivers were installed on a remote buoy and a moving ship off the coast of New Jersey to show how the distance between objects can be determined with GPS (Doutt et al., 1998). The researchers compared the GPS coordinates from the buoy's receiver with those of the two receivers on the ship. Distances between the buoy and each of the ship's receivers were calculated, while the distance between the ship's receivers remained constant. These three lengths allowed for a triangulation to be used to determine the ship's distance from the buoy with centimeter-level accuracy at a distance of 5 km (3.1 mi). By installing individual GPS units within each cotton harvesting subsystem, the position of each machine could be known relative to the others. For example, a harvester subsystem could wirelessly request GPS coordinates from all available harvesting vehicles during dumping, and then upon receiving the data it could compare other machine positions to its own position. By simply subtracting corresponding latitude and longitude values the system could identify the machine closest to the harvester and therefore the one receiving its basket of cotton.

Application to Cotton Harvesting

After reviewing the foregoing sensor options it is apparent that a cotton harvester must be modified to some degree in order for any of the options to work. For a given design to be practical, the level of modification needs to be minimized. Additionally, the system should be kept as simple as possible so that the harvester operator is capable of making repairs if necessary. Moreover, in the reviewed literature, all of the sensors experienced signal noise as the associated machines were used in their applications, limiting the sensors' accuracy. The rough terrain of a cotton field is similar in this regard to the environments in which these systems were tested. Such rough conditions can and do cause instruments to be out of calibration, causing the data collected to be inaccurate. For all of these requirements (minimizing harvester modification, simplifying the sensing system, and providing a rugged yet accurate sensing system) to be met, a single system like those discussed here would not be sufficient. For example, measuring the distance a hydraulic cylinder is extended requires a large amount of space, which is not available on a cotton harvester due to the close tolerances of other devices immediately surrounding the hydraulic cylinders. The Han et al. (1994) pinger system could have problems with extraneous signals due to the noisy environment aboard a harvester. Similarly, a contact type sensor would experience many instances where the terrain of the field may cause erroneous readings.

METHODS AND MATERIALS

OBJECTIVE 1

With respect to objective 1, several existing position measurement systems were examined in an effort to select one that could be adapted to a cotton harvester in order to sense the dumping action of the basket. Keeping in mind the various issues that may occur during cotton harvesting that could affect the accuracy of automated wireless signal transmission such as vibration, field slopes, and incomplete dumps, it became apparent that no single existing system would produce the desired results. As mentioned previously, false or incomplete dumps may be experienced when the harvester's basket is raised and only part or none of the cotton is dumped. By using two sensing devices in conjunction, a basket-position indicator and a basket-weight indicator, false dump signals can be avoided, allowing wireless signal transmission to be initiated only when appropriate. Two load cells (basket-weight indicator) and an inclinometer (basket-position indicator) were selected to automatically signal that a basket dump has taken place. An inclinometer uses the principles of a pendulous sensor that can determine an object's angle of rotation from an initial position. The inclinometer was affixed to the outside, back vertical wall of the harvester's basket, while the two load cells were placed under the non-pivoting side (i.e., the side that is raised and set back down) of the harvester (Figure 4). The inclinometer is the primary sensor, used to determine whether the harvester is in the process of dumping. The load cells are secondary sensors and determine whether any cotton is removed from the basket while the basket is in the unloading position.

Figure 4. Mounting locations of sensors

Maintaining the system's ability to be used on most brands or models of harvester, boll buggy, and module builder is also important and can be accomplished by developing the system to be stand-alone, not drawing power and I/O signals from inherent electronic systems on the harvester, boll buggy, or module builder.

Design of Sensing System

Prior to selecting any specific sensors, a data acquisition system was selected to accommodate multiple sensors as well as store harvest data and control system functions. The data-acquisition system is based on a single-board computer (SBC) (MicroPod, RLC Enterprises Inc., Paso Robles, CA) that uses the Windows CE operating system. The data-acquisition system has the capability of handling many tasks at the same time without slowing down the processing speed of the system. This system has multiple analog, digital, serial, and USB input ports through which sensor information can be gathered. All of the harvest data from the sensors are to be stored in a single data file to help with later processing.

Determining which load cells and inclinometer to use in this application required consideration of affordability, accuracy, and ruggedness. Field slope affects the accuracy of both the load cells and the inclinometer, so a maximum expected slope for a cotton field had to be determined. The 2005 to 2007 cotton production maps for the United States (USDA, 2008b) were used to glean field-slope data from the major regions of U.S. cotton production (Figure 5).

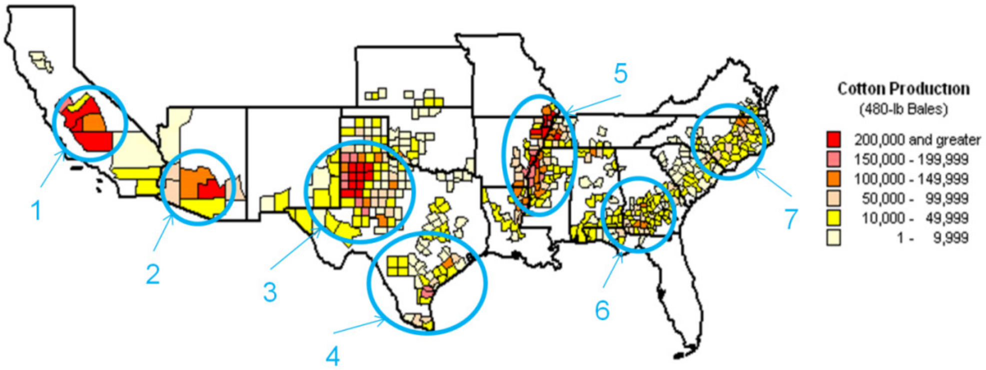


Figure 5. Seven major cotton producing regions of the United States

Soil surveys (USDA, 2008a) for each of the seven regions were obtained, four 10,000 acre plots were marked off at random in each region, and the maximum expected slope was found. In some regions with greater relief, extreme slopes were occasionally present (greater than 35%), but it was assumed that cotton would not be grown in such areas so they were ignored. Thus, non-extreme slopes from the 28 areas of interest were considered, and a maximum expected slope of about 12% was determined.

In addition to maximum expected field slope, the angle of harvester-basket rotation for dumping was needed to select an appropriate inclinometer. Since a John Deere 9965 cotton picker was to be used for the initial installation, the dumping angle for that harvester was determined to be 80°. Combining this angle with a maximum slope of 12% (~7°), the basket rotation was calculated to be a maximum of 73° to 87° depending on the slope of the ground. The H4-Series inclinometer (H4A1-70, Rieker Inc., Aston, PA) can detect ±70° from a zeroed state. It was assumed that any time a cotton harvester's basket rotates past 50°, it is in the act of dumping a load of cotton. Therefore, this inclinometer's maximum detection of 70° was deemed adequate. The inclinometer selected has a mechanical zero adjustment for calibration, and it was calibrated by zeroing it on a level surface as follows. The inclinometer was attached, along with a level, at the desired position on the picker's basket, with the picker sitting on an apparently horizontal surface. The basket was then raised approximately 76 mm (3 in.), to a position where the level read zero slope, and the output reading from the inclinometer was then set as zero.

To determine the required capacity of the load cells, the weight of both the basket and any cotton in the basket had to be accounted for. It was assumed, based upon discussions with a representative (Warnshozl, 2008) from the John Deere agricultural machinery company, that a typical cotton harvester's basket weighs about 453.6 kg (1,000 lbs) and that a large basket could hold about 34 m^3 (1200 ft^3) of cotton. Assuming in-basket seed-cotton bulk density of about 117.7 kg/m^3 (7.4 lb/ft^3) (Case IH, 2008), it was calculated that about 4000 kg (8880 lbs) of cotton would be present in the basket when it is fully loaded. A free body diagram (Figure 6B) was created to determine how much of the maximum 4453.6-kg (9,880-lbs) load would be carried by each load cell at the maximum slope.

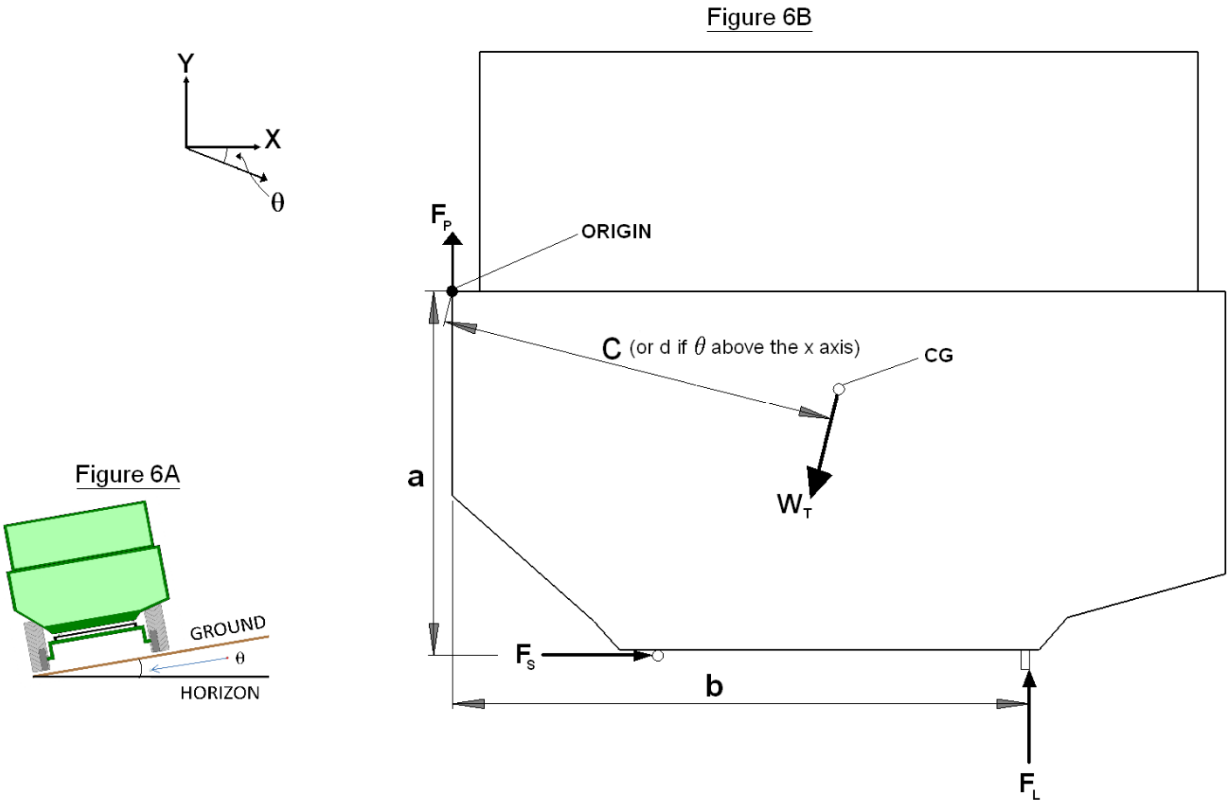


Figure 6. John Deere 9965. (a) Example harvester on a slope; (b) Free body diagram of cotton harvester basket

The origin in this free body diagram was placed at the pivot point of unloading the basket. The x-axis and y-axis were defined according to the basket frame lines, so it should be noted that the angle (θ) in Figure 6A is considered below the x-axis. Based on the diagram, Equations 1 through 8 were developed to calculate how much of the total weight would be carried by each load cell. As θ increases, the perpendicular distance between the line of force of the weight (W_T) through the center of gravity (CG) and a parallel line through the origin, distance c, will decrease. This decrease is caused by the line of W_T's rotating clockwise towards the origin. Since θ can be measured above or below the x-axis depending on the direction of slope of the field (i.e., the field slopes down and to the right or left, respectively), two sets of force equations were developed. Equations 1 through 4 are constructed only for measurements below the x-axis (see Appendix A for equation development).

$$F_S = -W_T\cos(270 - \theta) \tag{1}$$

$$F_L = \frac{W_T\left(c + a\left(\cos(270-\theta)\right)\right)}{b} \tag{2}$$

$$c = \sqrt{x^2 + y^2} \tag{3}$$

$$F_P = -\left(\frac{W_T\left(c + a\left(\cos(270-\theta)\right)\right)}{b} + W_T\sin(270 - \theta)\right) \tag{4}$$

where:

F_L = composite force experienced by load cells

θ = slope of the terrain

ϕ = direction which F_P acts on the pivot point

W_T = weight harvester basket and cotton

F_S = force experienced by basket's stop bar

F_P = force experienced by pivot point

x = x-coordinate of the CG

y = y-coordinate of the CG

a = vertical distance between origin and F_S

b = horizontal distance between F_S and F_L

c = distance between CG and origin for angles below x-axis

Equations 5 through 8 are constructed only for measurements above the x-axis.

$$F_S = -W_T\cos(270+\theta) \tag{5}$$

$$F_L = \frac{W_T\left(d+a\left(\cos(270+\theta)\right)\right)}{b} \tag{6}$$

$$d = \sqrt{x^2+y^2} * \left(\sin\left(\theta+\tan^{-1}\left(\frac{y}{x}\right)\right)\right) \tag{7}$$

$$F_P = -\left(\frac{W_T\left(d+a\left(\cos(270+\theta)\right)\right)}{b} + W_T\left(\sin(270+\theta)\right)\right) \tag{8}$$

where:

d = distance between CG and origin for angles above x-axis

As cotton fills the basket, y increases as the level of cotton in the basket rises. This results in a decrease in distance between CG and the origin, which can be deduced from Figure 6B. The coordinates for the center of gravity were determined through modeling in SolidWorks. First, a model of the basket was created with dimensions from the John Deere 9965 harvester. Next, 453.6-kg (1,000-lbs) increments of cotton were notionally placed into the basket, and SolidWorks was used to determine the CG location at each increment.

Table 1. Example calculation of forces present

Variables	Equations	Values	Units	Notes
a	Constant	72.00	in	*Basket dimensions
b	Constant	106.00	in	*Basket dimensions
ϕ	Constant	90.00	deg	*Direction Fp acts
W_T		4000.00	lbs	*Selected value for modeling
x		69.89	in	*Dependent on cotton load
y		-30.40	in	*Dependent on cotton load
θ		8.00	deg	*Selected value for modeling
c	$= \sqrt{x^2 + y^2} * \left(\cos\left(\theta - \tan^{-1}\left(\frac{y}{x}\right)\right)\right)$	64.98	in	*Distance between CG and origin for angles below x-axis
F_P	$= \frac{W_T(b * \sin(90 - \theta) + a * \cos(90 - \theta) - c)}{b}$	1887.17	lbs f	*Force experienced by pivot point
F_S	$= W_T \cos(90 - \theta)$	556.69	lbs f	*Force exerted on basket's stop bar
F_L	$= W_T * \sin(90 - \theta) - F_P$	2073.91	lbs f	*Force exerted on load cells
%	$= 100 * \left(\frac{F_L}{W_T}\right)$	51.85	N/A	*Percentage of total load carried by load cells

The percentage of total basket load carried by the load cells at various slopes was calculated by inserting varying distances between the line of W_T and a parallel line through the origin. This calculation was made at six loading levels: empty, 453.6 kg of cotton, 907.2 kg of cotton, and so on. Inserting the variables determined with SolidWorks modeling into Equations 1 through 8, a percentage of the total basket load carried by just the load cells was calculated. Table 1 is an example of the force values determined with these equations. The example is based on arbitrary selection of values for the total weight (W_T) and slope angle (θ). After determining the percentage of the load carried by the load cells, it was observed that the same loading trend occurred no matter how much weight was present in the basket.

In Figure 7, the y-axis represents the percentage of total weight carried by the load cells. It is clear from the figure that whenever the load cells are on the low side of the slope (i.e., θ is above the x-axis), they carry a larger percentage of the total weight as shown by the blue curve. The loading in this case increases slightly as slope increases up to about 7° and then drops off. However, if the load cells are on the high side of the slope (i.e., θ is below the x-axis), they carry a smaller percentage of the total weight, as shown by the lower curve. In this instance, as the slope of the terrain increases the load carried by the load cells decreases significantly and linearly. With two load cells' sharing the load, each one would carry a maximum of almost 35% of the total load, or about 1550 kg (3420 lbs). However, this is only true if the cotton harvester is level lengthwise; if the front of the harvester is higher or lower than the rear, the loads carried by the load cells will differ. To ensure that the load cells used would be capable of handling reasonably foreseeable circumstances, load cells with 2270-kg (5,000-lb) capacities were selected, allowing for about a 50%

safety factor. The LC307 Series (LC307-5K, Omega, Stamford, CT) top-hat style compression load cell was selected because of its high capacity and low profile of only 15.24 mm (0.6 in) in height. A low-profile load cell was preferable because it would not significantly alter the base-level tilt angle of the basket.

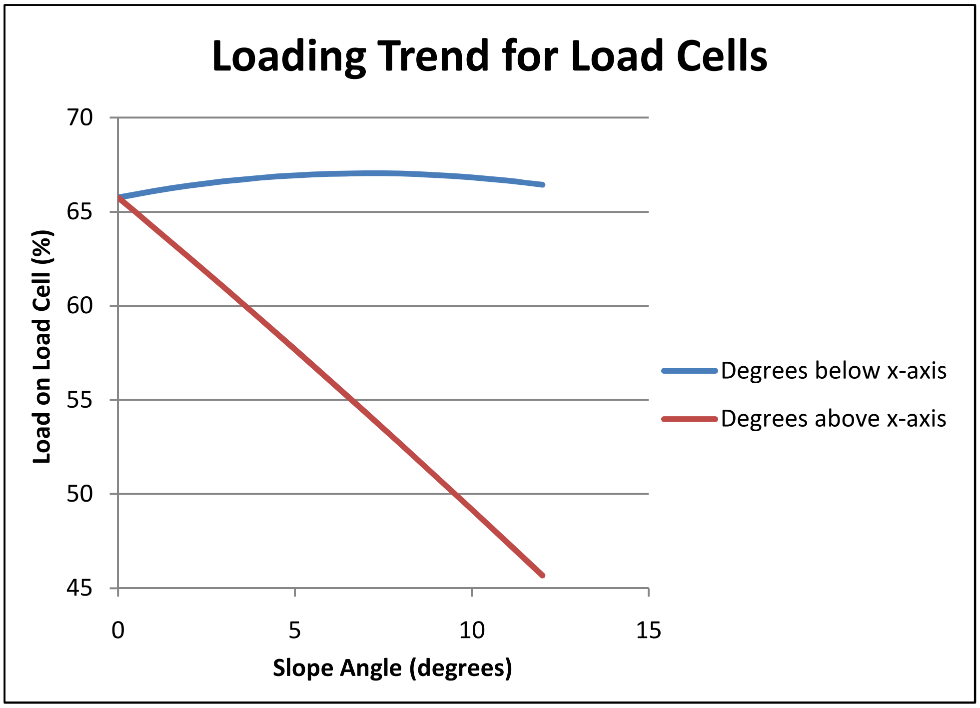


Figure 7. Loading trend experienced by load cells on various slopes

A load cell acts basically like a resistor with resistance that varies with load, such that when an increasing load is applied to it, the voltage across it increases. Determining the output voltage from a load cell can require reading a single voltage value or reading two voltage values and then calculating the difference between them. The voltage range that a load cell covers, from no load to maximum load, can be several volts or a few millivolts. Preliminary testing and calibration of the load cells was completed in the laboratory. A hydraulic press (4350L, Carver Inc., Wabash, IN) was used to determine the load cell output voltages at 453.6-kg (1,000-lbs) increments. The corresponding voltage outputs were then measured with a multimeter (112 True RMS Multimeter, Fluke Corporation, Everett, WA) . The voltage range covered by the load cells used in the WMTS was only 8mV (Figure 8). The other sensors incorporated into the WMTS have an output voltage range of zero to five volts. Since the load cells had a smaller voltage range than the other sensors, their output needed to be amplified so changes in weight would be within a reasonable input range for the data-acquisition system. Due to the linear nature of the load cell output (Figure 8), an amplifier could easily be constructed to increase the output voltage to a level appropriate for the data acquisition system. A range of 2 V was determined to give the desired output of 0.4 V per 453.59 kg (1,000 lbs) on the 12-bit analog-to-digital conversion within the data-acquisition system.

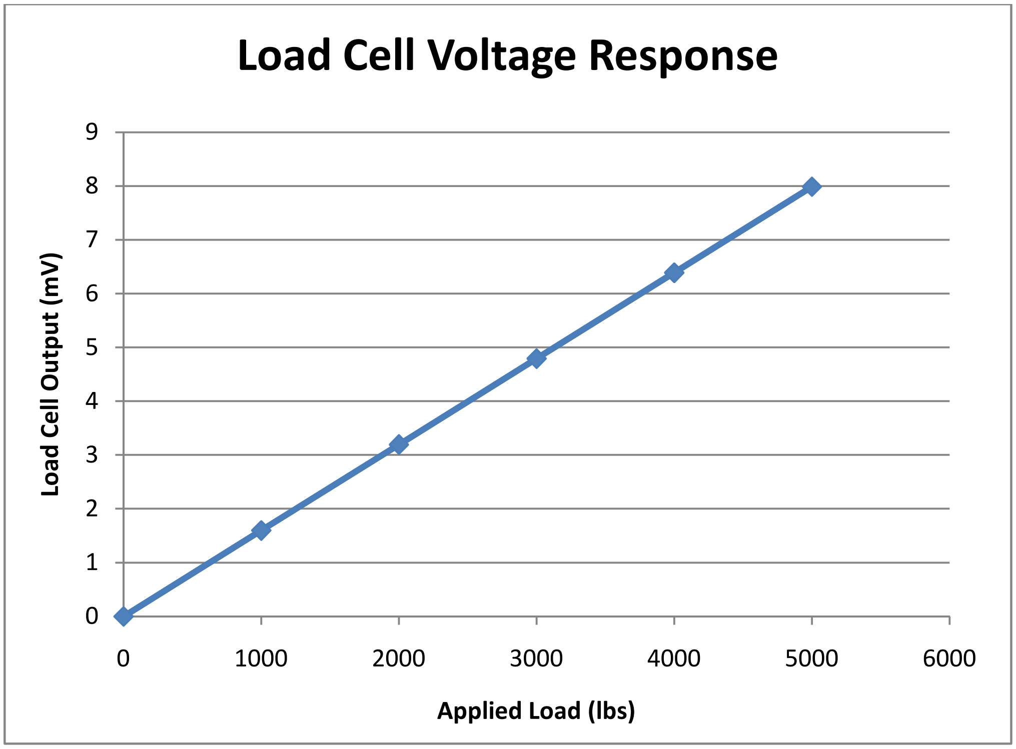


Figure 8. Load cell voltage output at varying loads

The measurement circuit for the load cells (Figure 9) was designed to amplify the maximum load cell voltage of 8 mV to about 2 V, allowing the user to clearly observe changes in cotton weight. Since the load cell output is determined from the difference between positive and negative output signals, a differential measurement circuit was needed. Operational amplifiers (LM2904N, STMicroelectronics, Geneva, Switzerland) (op amps) A and B are follower op amps, which do not amplify the magnitude of the input signals but instead help to stabilize them for further processing. Two differential op amps (C and D) placed in series follow A and B in order to amplify signal magnitude and produce the differential signal. An integrated circuit (AD680JTZ, Analog Devices, Norwood, MA) (IC) was used to regulate the negative input voltage (V_{REF}) for differential op amp D. Also, to filter out some of the electronic noise associated with mechanized field activities, capacitors were added. These capacitors are to attenuate unwanted signals by smoothing out the input signal. C_1 was placed in series with the incoming amplifier power to attenuate power surges that can occur when the hydraulic controls are used or the engine is started. Additional capacitors were used on the differential operational amplifiers to create low pass filters which smooth the output signals that they produce. By selecting low value capacitors (i.e. 300 pF), the cutoff frequency (f_c) of the low pass filter will be just under 20 kHz as determined from Equation 9. Therefore, the high frequency signals produced by machine vibrations or the terrain (high kHz – low MHz) of the field are largely eliminated. This noise reduction occurs because of the low impedance value of the capacitor at high frequencies, resulting in the attenuation of these signals.

$$f_c = \frac{1}{2\pi * R * C} \tag{9}$$

With the input and desired output voltages in mind, Equations 10 through 12 were used to determine the required resistors. Each of the variables in Equations 10 through 12 corresponds to a component or node within the amplifier schematic (Figure 9).

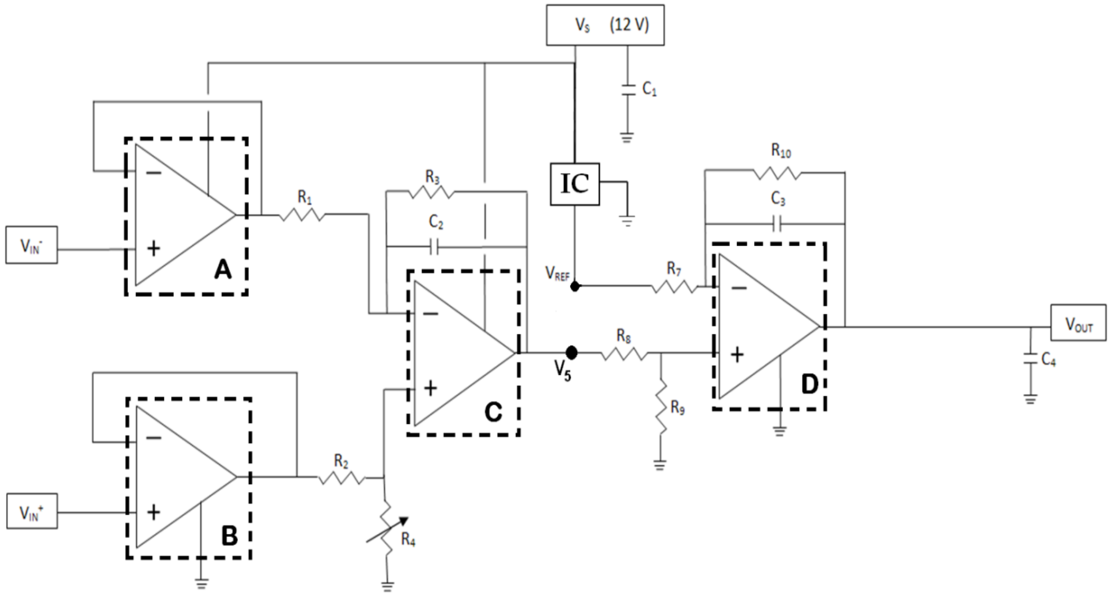


Figure 9. Load cell amplifier circuit schematic

Individual selected component values can be seen in Table 2. The first differential amplifier (C) increased the input signal 0.03 V for every 1 mV input voltage. The second differential amplifier (D) further increased this output (V_5) to a gain of 0.215 V/mV. These gains result in an output voltage range of 1.72 V as compared to the original range of only 8 mV.

$$V_5 = V_{IN^+}\left(\frac{(R_3+R_1)R_4}{(R_4+R_2)R_1}\right) - V_{IN^-}\left(\frac{R_3}{R_1}\right) \qquad (10)$$

$$V_{REF} = V_S\left(\frac{R_6}{R_6+R_5}\right) \qquad (11)$$

$$V_{OUT} = V_5\left(\frac{(R_{10}+R_7)R_9}{(R_9+R_8)R_7}\right) - V_{REF}\left(\frac{R_{10}}{R_7}\right) \qquad (12)$$

Table 2. Resistor and Capacitor values for load cell amplifier

Component ID	Value	Units
R1	1.0	kΩ
R2	1.0	kΩ
R3	27.0	kΩ
R4	50.0	kΩ
R5	900.0	Ω
R7	1.0	kΩ
R8	1.0	kΩ
R9	15.0	kΩ
R10	15.0	kΩ
C1	2.2	mF
C2	331.0	pF
C3	331.0	pF
C4	47.0	μF

After the circuit was designed a circuit board was designed in SolidWorks so that the circuit layout could be later imported into the CircuitCam plotting program. Within CircuitCam, the various cutting tools were specified to create the desired circuit board. Then the circuit board definition was imported into the BoardMaster cutting program. This program controls the computer numerical controlled (CNC) circuit board plotter (ProtoMat S42, LPKF Laser & Electronics, Hannover, Germany), which cut the circuit pattern into a copper plated board. Components were then installed on the finished amplifier circuit board (Figure 10) according to the diagram shown (Figure 9).

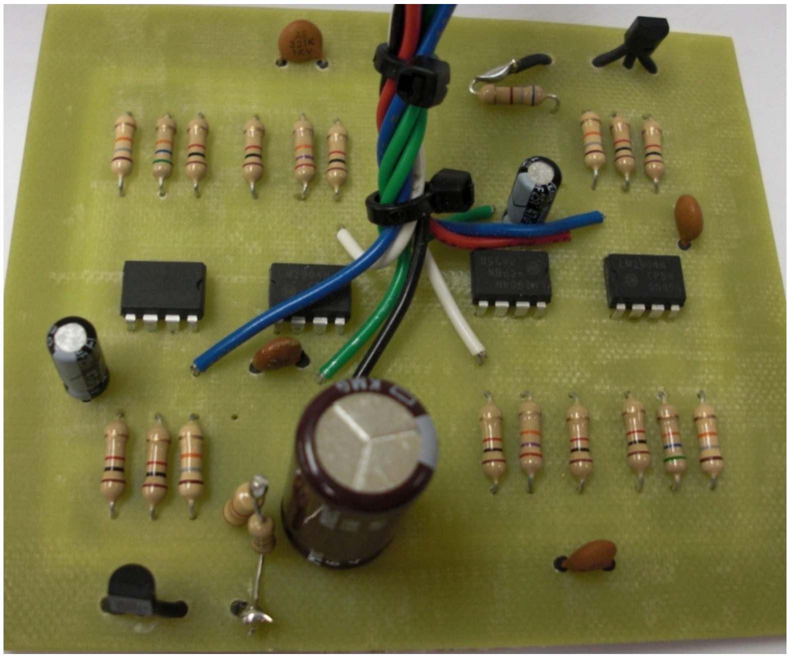


Figure 10. Load cell amplifier

The final device required by the WMTS was a GPS receiver, which provides detailed position data that the field-harvest position of each small amount of harvested cotton can be recorded. This capability is critical in relating specific areas of the field to specific modules so that module maps and fiber-quality maps can be created. The GPS receiver selected was a Global Sat MR-350 (City of Industry, CA). A bracket was needed to mount the GPS antenna on the light bar of the cotton harvester (Figure 11). By mounting the GPS antenna at this height on the harvester there is less chance of losing satellite reception that is required by the GPS receiver. Also, the wireless transceiver's antenna will be incorporated into this bracket to increase the transmission distance of the transceiver.

Figure 11. GPS antenna and wireless transceiver (WT) antenna bracket

Software Modification

The software from the existing WMTS had to be adapted to trigger message transmission based on the newly incorporated sensors. Microsoft Visual Studio 2005 was used to write all of the program code in Visual Basic. The software for the WMTS was broken into six subroutines. The primary subroutine ('MainForm') allows the user to access the remaining five subroutines such as the information subroutine 'FrmAbout'. Within the 'FrmAbout' subroutine is information regarding the software version and copyright data. The ‘HarvestInfo’ subroutine allows for the user to input harvest criteria such as number of boll buggies and module builders, number of rows harvested per pass, and the row spacing on which the cotton was planted. All of these inputs are used after completion of the harvest to produce accurate module and fiber quality maps. From the ‘HarvestInfo’ subroutine the ‘Harvesting’ subroutine is accessed. This subroutine runs during harvesting and gathers and records data from the various sensors. For ease of processing, each basket of cotton harvested has its own computer data file, and all of the files from a given day are stored in a common folder. Thus, a post-processing step (‘PostProc’ subroutine) is required upon completion of a single day’s harvest; this step combines all the individual basket data from that day into a single file and pairs each basket with a module identification number. The final subroutine (‘RtnHvst’) enables the user to return to a field that has previously undergone harvesting operations and begin harvesting again without having to enter any harvest information. For instance, if a producer started harvesting a field on Monday, all information for that field should have been input into the WMTS on Monday so that on Tuesday, when harvesting continued, the information would already be available within the WMTS. This capability exists because each time harvest information is entered it is saved.

A flowchart of how outputs from the sensors determine what the system does can be seen in Figure 12. When the HSS program is initiated, the basket count is set to 1, which indicates a new harvest. If it were a return harvest, then the basket count would be set to the last basket number from the previous harvesting day. Sensors then begin to provide output data to the WMTS, indicating the amount of cotton within the basket, the basket’s position with respect to the horizontal, and the harvester's GPS coordinates and speed. Every 1.0 seconds the outputs from each sensor are combined into a single statement that is stored within the basket file. The various sensor outputs are separated by commas to allow for the message to be parsed later.

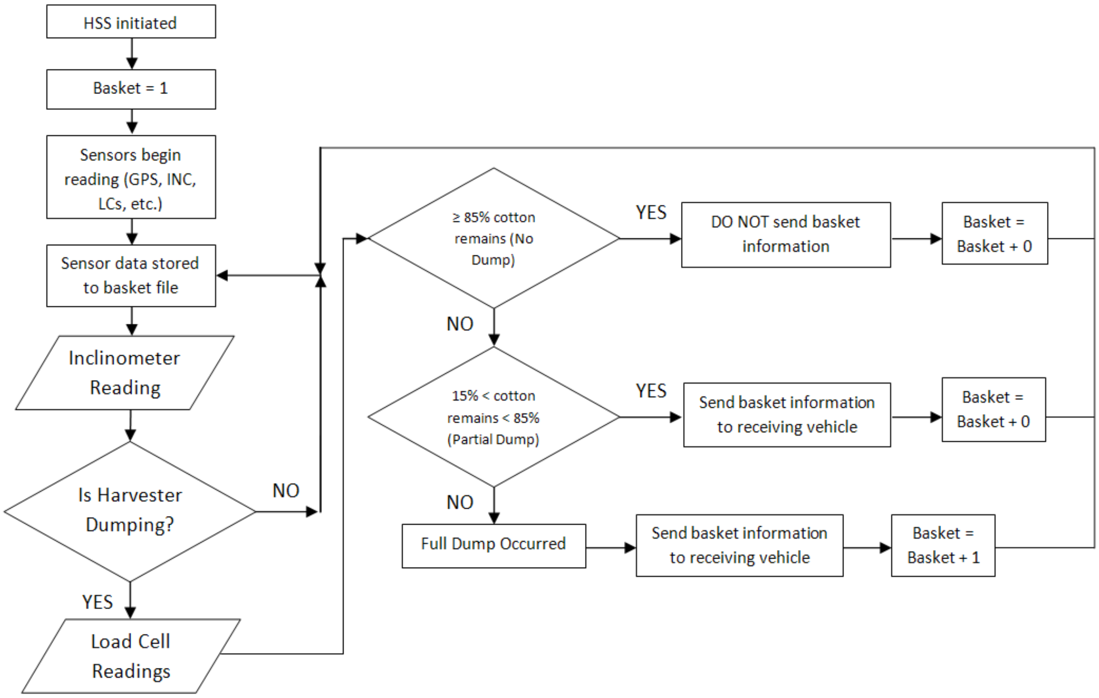


Figure 12. WMTS flowchart

To deal with the situation that can arise when a significant portion of the cotton has been removed from the basket but a significant portion still remains, the software directs the same basket number to be used for the current dump and the next dump. A partial dump is defined as occurring when between 15 and 85% of the cotton remains in the basket, as determined with the load cells.

Testing of Automated System

For testing automation of the WMTS, the sensing system was added to only the harvester and not a boll buggy. A 50.8-mm (2.00-in) by 76.2-mm (3.00-in) piece of rectangular tubing was affixed to the basket support beam on the cotton picker (9965, John Deere, Moline, IL), and the load cells were attached to it (Figure 13). Two metal contact points were placed on the bottom of the cotton harvester's basket, one for each load cell. The contacts prevented any other part of the basket from touching the support beam, enabling the entire localized weight of the basket to be transferred through the contact points. The contacts were oriented so as to rest on top of the load cells when the basket is in the down or 'seated' position. Installation of the load cells was tedious, and therefore their installation should generally be considered permanent. On the other hand, the data-acquisition system (DAQ) and inclinometer were easily installed, and the DAQ can be easily removed from the harvester with the sensors being kept in place, unplugged from the data-acquisition system.

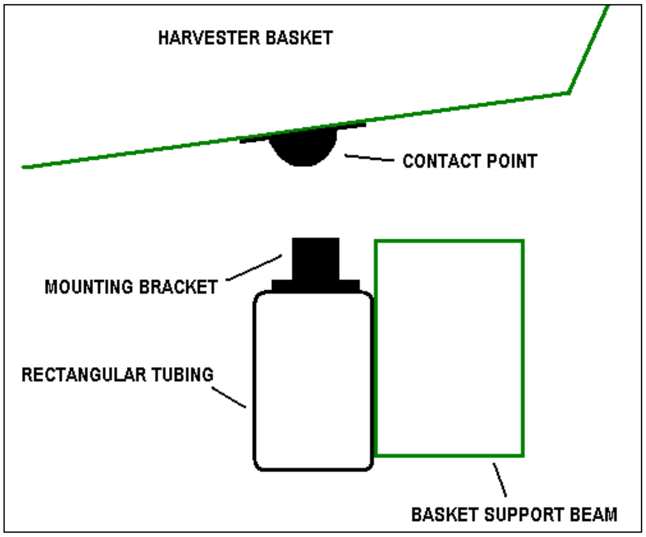


Figure 13. Load cell mounting setup (John Deere 9965)

The automated WMTS was installed and tested first on a cotton picker used for the harvest at Texas A&M's IMPACT Center research farm near College Station, TX, and later on a cotton stripper (7450, John Deere, Moline, IL) at a farm near Lubbock, TX. After mounting, the system was tested prior to harvesting. Only the unloading of cotton was simulated since it was difficult to vary the weight and simulate the accumulation of cotton in the basket. The cotton harvester's basket was raised and lowered to simulate the unloading of cotton in order to confirm the successful transmission of a wireless message. Also, to ensure that the load cells were working properly, the change in voltage between the basket's down and up positions was observed.

The test near College Station took place from September 22 through 25, 2008 and consisted of approximately 32 ha (80 ac) of harvested cotton. As noted previously, no boll buggy was used during the testing period, but only the cotton picker and a single module builder (CBSK Module Builder, Crustbuster Speed King, Dodge City, KS). Each day prior to the start of harvest the WMTS was initialized and data collection began. Each day during the filling of the first basket of cotton a researcher sat in the cab of the cotton picker to ensure the system worked correctly by observing changes in output voltages from the sensors as well as the received wireless messages. On subsequent baskets, the harvester operator was consulted about the condition of the system during the unloading of cotton. Once the harvesting was completed each day, the data were downloaded from the data-acquisition system and analyzed. With the data recorded during the harvest as well as the information from the classing office following ginning, yield and fiber-quality maps were produced.

System Refinement

Initial testing at College Station revealed problems with the load-cell mounting setup (1) lateral basket motion caused the contact point to be misaligned with the load cells, and (2) wireless signals from surrounding devices were detected by the wireless transceiver. Therefore, two changes were made to the WMTS prior to harvesting in Lubbock. First, the load cell mounting setup was redesigned, and the software was modified so that only wireless signals from the WMTS could be recorded by the wireless transceiver. Modifying the existing software involved adding a message-header-based filtering function to each subsystem.

Table 3. Wireless message header designation

Header	**Cotton Transfer**
HTOB	Harvester to Boll Buggy
HTOM	Harvester to Module Builder
BTOM	Boll Buggy to Module Builder
MTOH	Module Builder to Harvester

Message headers are sections of text at the beginning of a message that can be used to identify the type of message. The headers shown in Table 3 were used in pre-RFID versions of the WMTS software to distinguish whether the messages sent from the harvester were intended for either the module builder or boll buggy. Each subsystem's filter accepted only one specific header from the messages detected by the wireless transceiver. The HSS's filter read every message received, and if the message did not contain the MTOH header, then the message was ignored.

Second, a new load-cell-to-basket contact-point concept was developed, which relocated the contact points from the bottom of the basket to the top of the load cell. When the contact points were on the basket, the basket had to be lowered into a precise position and could not move horizontally more than roughly 6.4 mm (0.25 in) from that location without sliding off the load cells. It became apparent that the basket and its connections to the frame flex and move more than this while the harvester traverses a field. Having the contact point on the load cell allows the basket to move significantly while staying in contact with the load cell. To ensure that a contact point evenly distributed its load to the load cell, it had to be the same diameter as the load cell. Also, to allow the contact point to move up and down with the load cell it had to be placed within the load cell's mounting bracket. Placing the contact point within the load cell mounting bracket also resolved the issue of how to attach the contact point. Figure 14 shows the contact point and load cell mounting bracket that were placed on top of the load cell and then attached to the harvester's basket support beam.

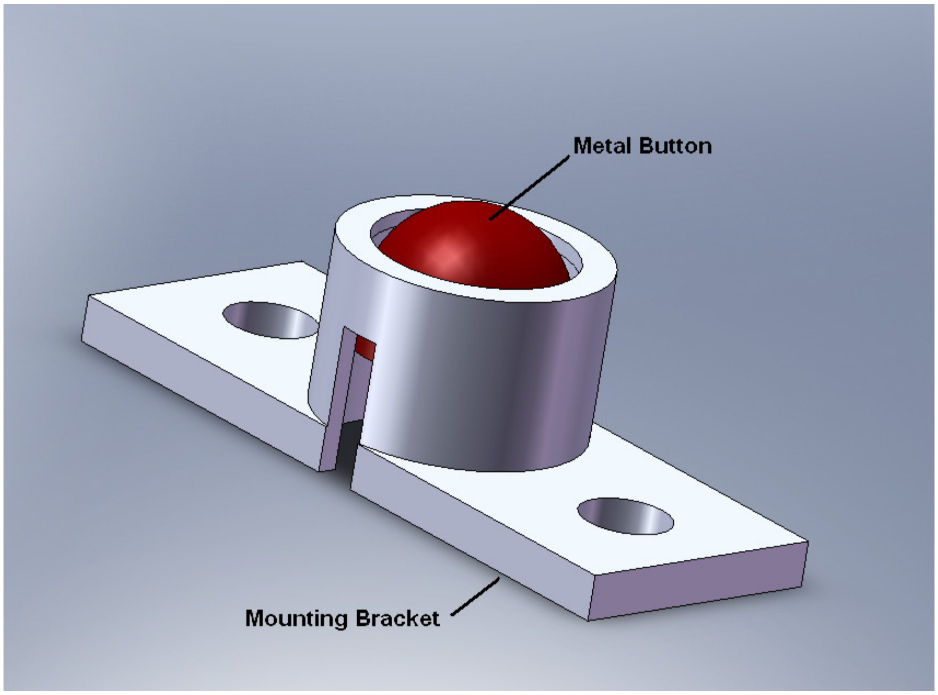


Figure 14. Load cell mounting system with metal button

The bottom of the metal button is a flat surface so as to maintain even contact between the load cell and button. Next, the mounting bracket is placed over both the load cell and metal button and welded to the basket support beam. Figure 15 shows the new mounting bracket and relocated contact point, as installed on a harvester.

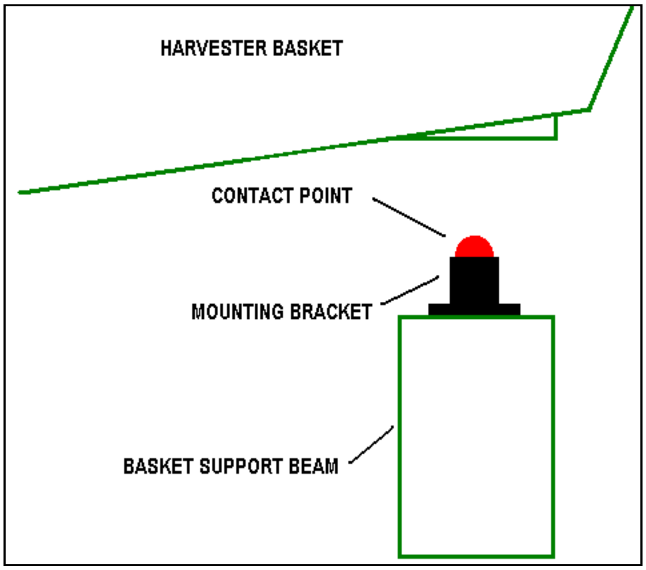


Figure 15. Revised load cell mounted on harvester

Testing and Modification of Refined System

The harvest near Lubbock took place from November 21 through December 7, 2008, and approximately 81 ha (200 ac) of cotton were harvested. For the entire testing period the cotton stripper dumped solely into a boll buggy (CBSK Boll Buggy, Crustbuster Speed King, Dodge City, KS) that dumped solely into a single module builder (Cmb 6932, Bush Hog, Selma, AL). Each day prior to the start of harvest, the system was initialized and data collection began. As at College Station, each day during the filling of the first basket of cotton a researcher sat in the cab of the cotton stripper to ensure the system was working correctly. After the first basket was collected the harvester operator was asked about the condition of the system during each subsequent unloading of cotton. Once the harvesting was completed each day, the data were downloaded from the data-acquisition system and analyzed. The harvest stopped for a two-week period to allow the cotton remaining in the field to further mature. During this time the load cells were removed from the harvester to be recalibrated. After testing the load cells in the laboratory, it was determined that the load cells' sensitivity voltage range had changed. Therefore, the amplifier had to be adjusted to the new voltage range. After this modification, the load cells were reinstalled on the harvester; however, in this installation the load cells were bolted to the basket support beam with 9.52-mm (0.375-in) bolts that were 101.6 mm (4.00 in) long.

OBJECTIVE 2

With respect to objective 2 – regarding multiple similar harvesting machines in a field – a requirement in designing the system was to develop a capability to determine which field machine(s) should receive transmitted signals when a dump occurs. Tracking an ID number associated with a basket of cotton can be accomplished by having the HSS send the ID to the boll buggy or module builder into which it is dumping; the receiving machine could potentially be recognized with the aid of GPS by determining which machine is nearest. Incorporating GPS units, even inexpensive ones, into each machine in the module tracking system would allow for the position of each machine to be known. Calculations could be conducted to determine proximity between machines to determine the receiving machine. However, in the event that two receiving machines are in close proximity to the dumping machine during a dump, the proximity calculation would not be able to determine which machine was the receiving machine. RFID presents a good alternative. RFID readers and tags can easily be integrated into the current WMTS with little modification to the current overall program code. The short and adjustable transmitting distance of RFID systems can reduce the chance of detecting the incorrect receiving machine. Moreover, the RFID reader's antenna can be positioned to scan for RFID tags in a specific direction, such as only the side of the harvester where the receiving machine would be positioned. This quality enables the RFID reader to determine which harvest machines are involved in the cotton transfer even in the situation previously described, unlike a GPS based setup. These qualities of RFID make it a more reliable and robust choice for the WMTS. RFID systems generally consist of readers and tags. A gain-adjustable RFID reader (2.4 GHz active RFID reader, Simple Technology Inc., Henderson, NV) was chosen for use with the WMTS. This reader was selected for its adjustable read distance, reliability, and rugged construction. Table 4 includes some of the reader's specifications. The specifications of the RFID reader indicate that it operates in two modes, allowing the RFID tag messages to be either received and uploaded to the host computer automatically (direct mode) or saved by the reader and uploaded to the host computer when the reader is prompted (buffering mode). Multiple RFID tags can be detected by the RFID reader, enabling it to differentiate among a number of machines, but the reader can also read them at the same time, requiring a robust algorithm to ensure to the proper tag is detected by the reader. Rewriteable RFID tags (2.4 GHz Rewriteable active RFID tag, Simple Technology Inc., Henderson, NV) were used because of their low power consumption and ruggedness. The low power consumption allows for a single RFID tag to last up to five years on a single battery.

Table 4. RFID reader specifications

Direction	Omni-directional, standard antenna
Read Range	0 - 120 m adjustable
Frequency	2.4 -2.5 GHz
Interface	RS232/485
Sensitivity	-90 dBm
Power	50 mA, 9V
Mode	Direct or Buffering
Operating Temperature	-40° ~ 80°C
Humidity	Up to 95% Non-condensing
Multi-Detection	Yes
Read Quantity	200 tags/sec

When the RFID system is implemented in the WMTS, each harvester will have an RFID reader that can detect multiple RFID tags. The HSS RFID reader must be able to read multiple RFID tags since the harvester can dump into a boll buggy or a module builder, and multiple units of each may be in the field. Boll buggies will be outfitted with both an RFID reader and an RFID tag since they receive and unload cotton. Finally, each module builder will have only an RFID tag, which can be detected by RFID readers on the harvester and the boll buggy. The RFID tags will be affixed to the vehicles on the side where they receive cotton from other vehicles. For example, a boll buggy receives cotton from a harvester on its right side (looking forward from the rear of the vehicle), and therefore the RFID tag will be on the right side of the boll buggy. The RFID tag will be placed on the boll buggy's frame approximately 0.3 m (1 ft) in front of the support wheel. On the module builder, the tag will be placed on the right side in the middle on a support rib to give the tag good visibility no matter whether the boll buggy or harvester is dumping in the front of the module builder or the rear. Similarly, RFID readers will be mounted on the side of the vehicle from where cotton is unloaded. Therefore, on a John Deere 9965, for example, the RFID reader would be mounted on the left side (viewing forward from the rear) of the cotton harvester. The shield covering the space underneath the basket, above the rear wheels is a location that would allow the reader to easily see the RFID tag with no obstacles in the way.

Software

Incorporating the multiple-machine RFID system into the existing WMTS required modifications to the overall software program code. The modified program flowchart has an added RFID subroutine (indicated by the dashed box in the figure below) that the program flow must go through before a wireless message can be transmitted (Figure 16). Other than the addition of this subroutine, the program functions just as it did during testing of automated message sending.

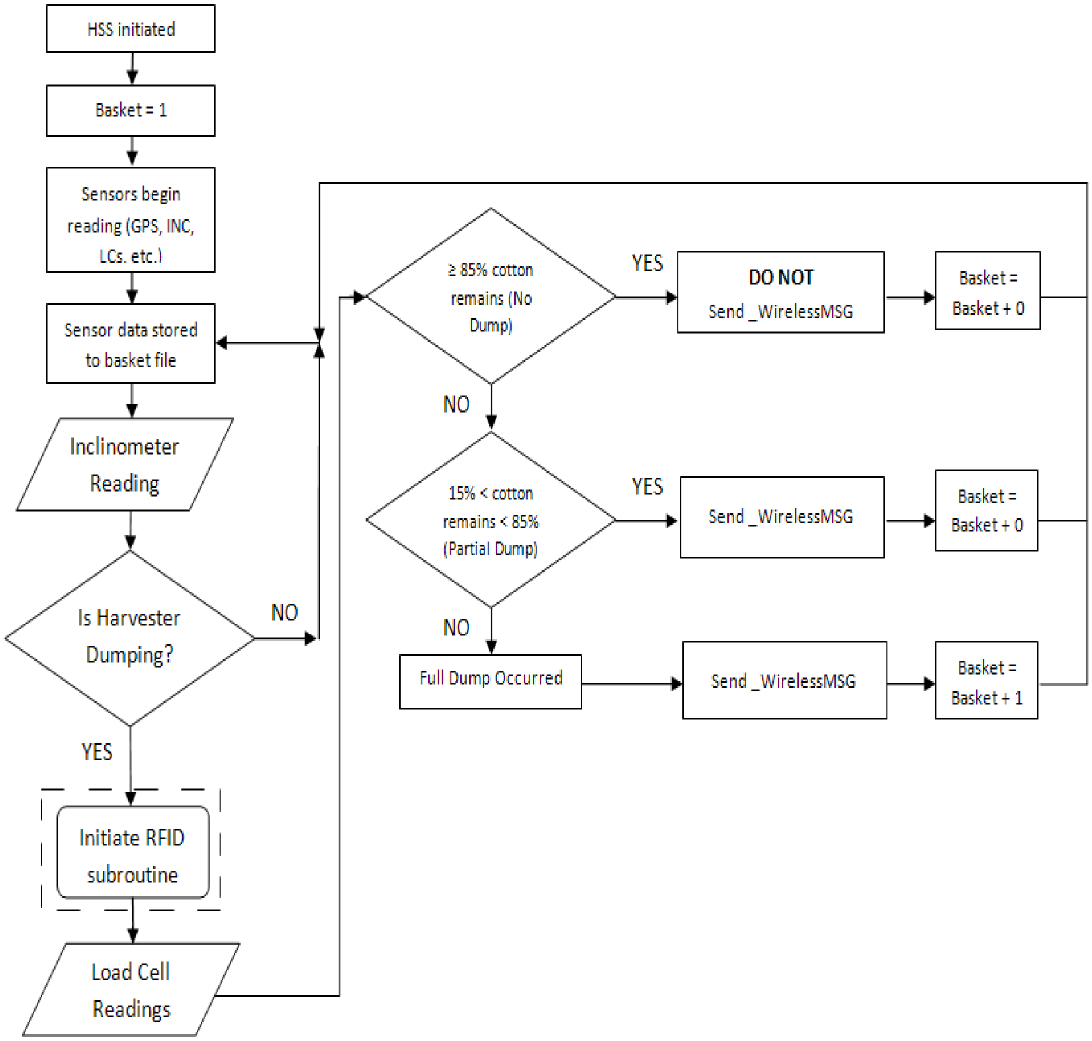


Figure 16. WMTS flowchart with RFID subroutine

Prior to inclusion of the RFID system, the WMTS did not add a receiving-vehicle identification number to the wireless message before broadcasting it. Only the harvester identification number and basket identification number were included. By forcing the WMTS to receive information from the RFID system before transmitting any information, a specific receiving vehicle can be assigned. The RFID subroutine shown in Figure 17 consists of three parts: scanning/receiving, pairing, and writing. When the subroutine is initiated, the RFID reader scans the surrounding area and receives tag information from any tags near the reader. The reader scans for RFID tags five times in a 1.0-s interval to ensure the proper tag is detected. To account for detection of multiple tags, the WMTS keeps track of the number of times that a tag is detected by recording tag numbers in a table (the TAG table). The program then chooses from the TAG table the tag that was detected the most times. This method is used to prevent a non-receiving vehicle's tag from being detected if it passes by the reader while a cotton transfer is occurring. The passing non-receiving vehicle typically does not stop moving, resulting in a reduced likelihood of detection for the non-receiving vehicle's tag. Upon receiving individual tag information, the subroutine compares the received tag ID to the preloaded vehicle-identification (VID) table that indicates the specific vehicle ID for the corresponding tag ID. This vehicle ID is then combined into a wireless message with basket information, and the wireless message is returned to the main program.

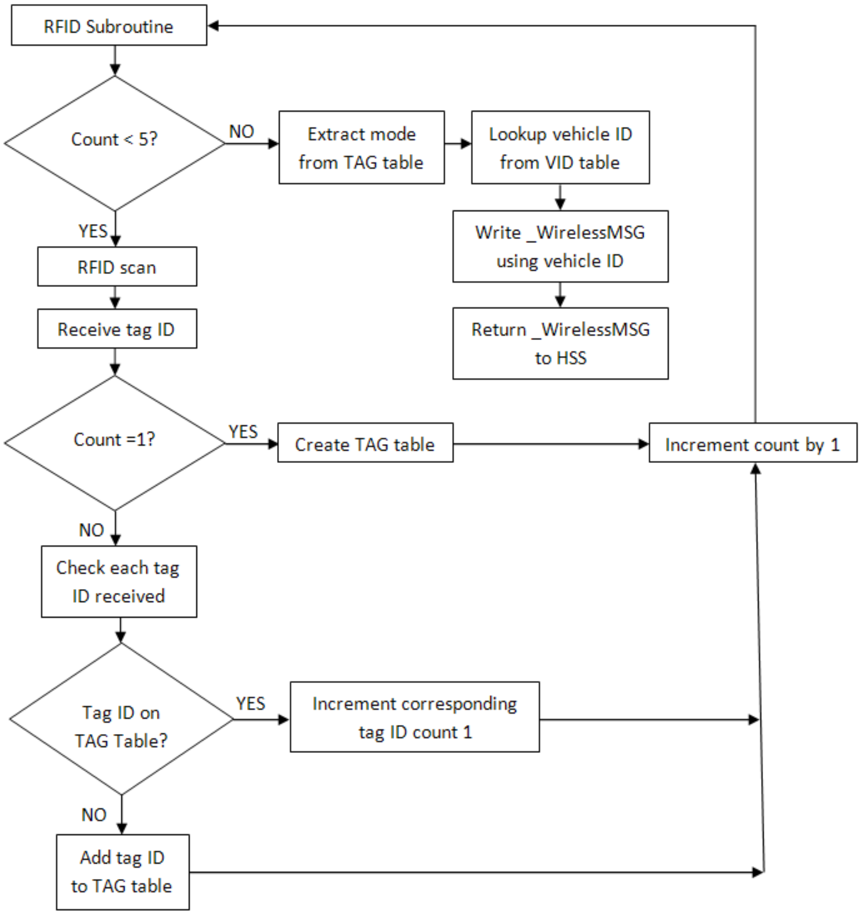


Figure 17. RFID subroutine

The WMTS determines with which subsystem to communicate based on the _WirelessMSG variable within the program. This variable consists of sending- and receiving-vehicle information, basket information, and module information. The protocol for the wireless message can be seen in Figure 18.

MSG	,	H1	,	00	,	H1005

Figure 18. Protocol for wireless message prepared by harvester

The first field of the wireless message is always ‘MSG’ indicating to all vehicles involved in the harvest that this is a harvest related message needing to be reviewed. In the second field of the message (H1), the vehicle that sent the message is indicated by two digits. While the message is being prepared the third field (receiving vehicle) is ‘00’ since the receiving vehicle has not yet been determined. The fourth field of the wireless message (H1005) indicates the cotton basket number as well as the harvester that created the basket. The ‘H1’ in the message indicates that (e.g.) harvester number 1 harvested the basket and (e.g.) the ‘005’ indicates that this is the fifth basket produced by this harvester. The receiving vehicle is identified with the information gathered by the RFID reader, and its corresponding two identifying digits are inserted into the third field of the wireless message. For example, if the aforementioned cotton basket were transferred to boll buggy number 2 (B2), the wireless message would appear as in Figure 19.

MSG	,	H1	,	B2	,	H1005

Figure 19. Wireless message broadcast by harvester after receiving vehicle is identified

Wireless messages broadcast by either harvesters or boll buggies are received by all of the vehicles involved with the harvest. Each vehicle subsystem parses the wireless message and retrieves the contents of the third field (receiving vehicle field). The vehicles then compare these contents to their vehicle identification, and the matching vehicle prepares a new wireless message with the appropriate information. Vehicles not matching the receiving-vehicle identification disregard the wireless message and take no further action. As with the HSS, when the BBSS prepares its wireless message, the third field (receiving vehicle) has the place holder ‘00’. Also, because the boll buggy is capable of holding multiple harvester baskets, the number of fields which are available is not limited. Additional harvester baskets are appended to the end of the wireless message as shown in Figure 20. In this example the sending vehicle is B2, the receiving vehicle is not yet known (‘00’), and there are two harvester baskets within the boll buggy. The first basket is from harvester 1 (‘H1’) and is the fifteenth basket produced by this harvester, while the second basket is from harvester 2 (‘H2’) and is its fifth basket.

MSG	,	B2	,	00	,	H1015	,	H2005

Figure 20. Wireless message being prepared by boll buggy

When the receiving vehicle’s ID is determined by the RFID reader, the message in Figure 20 has its third field filled in with that ID. When a basket of cotton arrives at the module builder, the MBSS produces the final broadcasted wireless message, which is to be received by the HSS from which the basket originated. This message is nearly identical to the wireless message from the BBSS (or HSS if a harvester is dumping directly to a module builder), but with an additional field attached to the end to indicate the module number.

The third field of this message will always be ‘00’ since the message is always broadcast to the originating harvester(s), and its ID is not/need not be determined with RFID. Instead, upon receiving the message, a harvester reviews the message, starting with the fourth field and on through the second-to-last field, to determine whether a basket from that harvester is included within the part of the module associated with the given message. Figure 21 shows an example of the wireless message sent from the module builder upon receiving a basket of cotton. The sixth field in this message (‘76541’) indicates the module number, which will be used later to indentify modules and bales after they go to the gin.

MSG	,	M1	,	00	,	H1015	,	H2005	,	76541

Figure 21. Wireless message broadcasted by module builder

Preliminary Testing

The testing of multiple-machine-capability took place at Texas A&M’s campus after the 2008 cotton harvest. As mentioned previously, the primary function of the RFID system is to differentiate among harvesting machines to ensure that wireless messages are transmitted to the correct machine, enabling baskets and modules of cotton to be tracked accurately. Tests must be performed to ensure the RFID system performs this function, to determine how sensitive the RFID system is, and to ensure that the RFID system is integrated with the WMTS such that the complete WMTS functions properly. Testing of the RFID system addressed four questions. Questions 1 and 2 inquired about how the RFID system operates, so that through proper design and construction it could be integrated into a system capable of differentiating among multiple mobile field machines. Questions 3 and 4 dealt with how well the system performs after incorporation into the WMTS. The first two questions are as follows:

1. How should the reader and tag be oriented on the harvesting vehicles to optimize their performance?
2. Do transmissions from the RFID reader or tag interfere with the wireless transceiver within the system or vice versa?

Addressing question 1 involved determining the scan area of the RFID reader's antenna, which searches for RFID tags in a hemispherical pattern away from the antenna's base. The antenna was placed on a flat vertical surface and positioned on a transmitting vehicle so that it scanned only the hemisphere in the direction where the receiving vehicle was expected to be. For instance, cotton is always transferred to the left side of the unloading vehicle; therefore, the antenna could be positioned to scan the left side of the vehicle and not the right. This strategy was expected to reduce the chance of detecting an RFID tag on a potentially receiving vehicle that was not actually receiving the cotton. The optimal orientation of the RFID reader's antenna on the harvester was determined by placing the antenna in various positions on a flat vertical surface on the harvester's unloading side. A single RFID tag was placed on the receiving side of a boll buggy. This boll buggy was then moved to ten different locations around the antenna on both the loading (positions 1 – 5) and unloading side (positions 6 – 10) of the harvester (Figure 22). This process was used to determine whether there were any major 'blind areas' where the reader could not detect the tag. Each of the ten locations was the same distance away from the RFID reader.

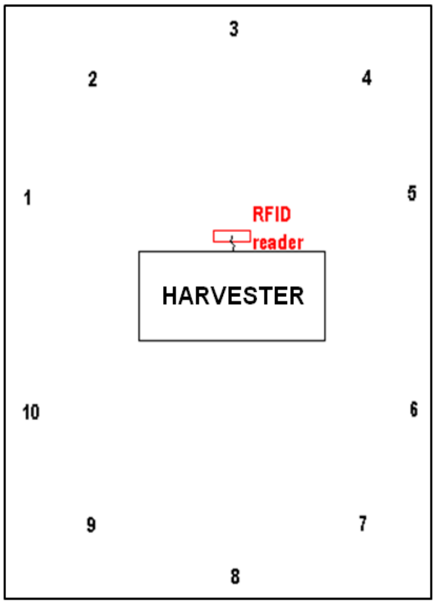


Figure 22. Tag and reader locations

A second RFID tag was then introduced into the system – both at locations on the unloading side farther away than the receiving vehicle, and at locations on the non-unloading sides at various distances, some closer and some farther away – and the reader was again tested for its ability to detect the appropriate tag. The receiving RFID tag was placed only at locations which it was detected in the previous tests. By positioning the antenna on a vertical surface it was expected that the detecting range of the RFID reader could be limited to only a specific direction.

After RFID reader orientation was established based on the foregoing tests, addressing question 2 was done in the lab by simulating inclinometer and load cell readings – just as for the message-sending-automation lab testing – to induce wireless signal transmission by the wireless transceiver. The RFID reader was set to active-scanning mode, while the wireless transceiver was in listening mode. Tests were conducted both with and without RFID tags present. With the RFID reader scanning the area and the wireless transceiver listening for signals, it could be observed whether the wireless transceiver inadvertently picked up any signals from the reader. Any signals detected by the wireless transceiver should then be attributed to the RFID system. Next, the reader was set to active scanning mode again and, with no RFID tags present, the WMTS was used to simulate a transfer of cotton. Observing the RFID reader's output within the WMTS program, it could be observed whether any messages from the wireless transceiver were detected by the RFID reader. Finally, a single RFID tag was introduced into the setup, and the test was run again. By completing this series of tests, it became possible to modify the WMTS software such that it would filter received data, enabling only relevant data to be collected by the wireless transceivers and RFID readers.

Post-Design Testing

Answers from questions 1 and 2 were used to integrate the RFID system into the WMTS. Then, questions 3 and 4 were used to determine the accuracy and reliability of the RFID system and the transmission and signals.

3. Does the RFID system repeatedly differentiate among the various harvesting vehicles?
4. Will RFID tags on other receiving vehicles interfere with the RFID tag on the receiving vehicle involved in the current cotton transfer?

Question 3, whether or not the RFID reader is capable of differentiating among the various harvesting vehicles, could be answered with the foregoing test of question 1 to determine whether the reader's antenna, having more than one tag positioned around it, is able to exclusively detect the ID number from the tag in the position of the receiving vehicle. Since the closest tag should always represent the vehicle into which cotton is being transferred, the program has the RFID reader scan for tags five times, and then it selects the most often detected tag as the receiving vehicle. Success in this part of the test would verify that the reader can exclusively receive the correct RFID tag's unique ID number in the presence of other tags. This capability is needed so that the RFID reader on the harvester can identify the proper boll buggies and module builders in the field. Preliminary testing revealed that previously detected RFID tags are stored within the RFID reader's memory for a short time which leads to the incorrect tag being detected the next time the RFID reader scans for tags. To solve this problem some code was added to the software to introduce a time-delay after a tag was detected so that the RFID reader could reset itself.

Regarding question 4, determining the effect tags on other vehicles have on the identification of vehicles involved in the transfer requires taking into account where vehicles not involved in the cotton transfer may be located. Surrounding vehicles involved with the harvest may be positioned around the two vehicles that are transferring cotton. To simulate this situation, the RFID reader was oriented according to the findings from question 1, with the scanning distance of the reader was set to 6 m (19.7 ft) to ensure vehicles farther than this away were not detected. The RFID tag was positioned 5 m (16.4 ft) away from the reader. This distance was chosen as a common separation distance between vehicles involved in a cotton transfer. Consider that an eight row cotton stripper set up for 0.91 m (36 in) rows is 7.32 m (24 ft) wide, resulting in a receiving vehicle's being about 3.66 m (12 ft) away from the harvester. In field-test simulations, the receiving vehicle was a truck used to represent an actual boll buggy or module builder. Vehicles not involved in the transfer of cotton should be expected not to pass within less than 5 m of each other, but a smaller distance could occur if another vehicle drove on the non-dumping side of the cotton harvester. To test the ramifications of this possibility, a non-receiving tag was placed in front of, behind, on the non-dumping side of the harvester, and also on the dumping side but with the actual receiving vehicle between them. The non-receiving tag was stationary in these locations for the initial testing. Secondary testing was completed in which the non-receiving tag was affixed to a truck and then driven past the four locations, creating an imaginary square around the two vehicles involved in the cotton transfer (Figure 23). Within Figure 23, NR is the non-receiving vehicle, U is the unloading vehicle, and R is the receiving vehicle, while x indicates the location of the RFID tag on the non-receiving vehicle. In all cases, the output of the RFID system was monitored to determine whether it detected only one tag and only the correct tag.

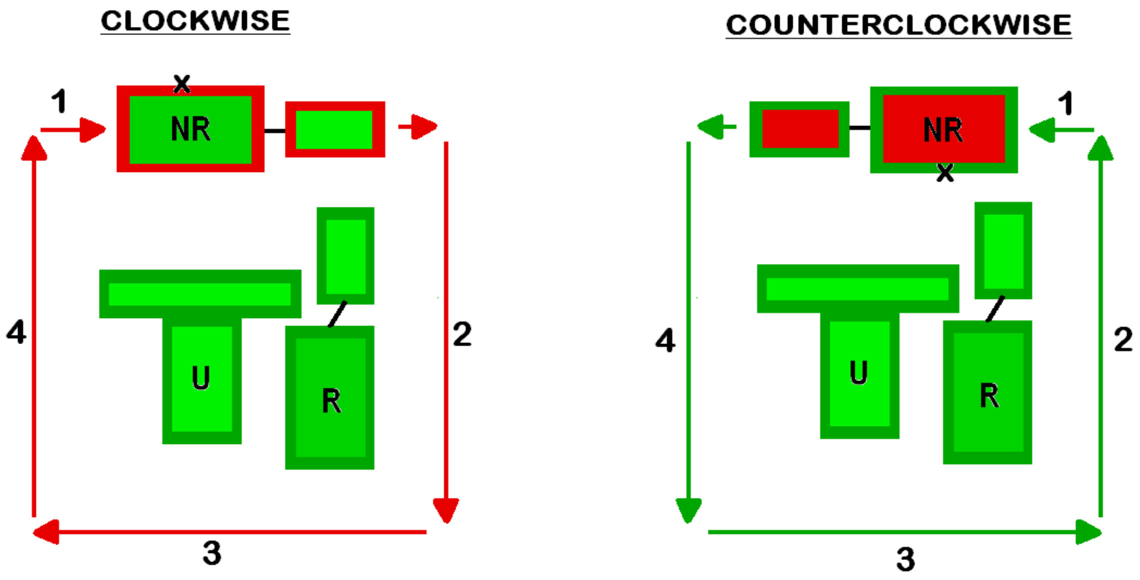


Figure 23. Question 4 testing diagram

OVERALL TESTING

After confirming that the individual components (*automatic message triggering and unique machine identification)* of the system worked separately, they were integrated together into a complete system. The completed system was tested by simulating the harvest process with one harvester, one boll buggy, and two module builders. Both the HSS and the BBSS were mounted on vehicles capable of moving around a large parking lot, while the MBSSs are mounted at stationary locations. This configuration enabled the HSS to move close to the BBSS or MBSS to simulate a transfer of cotton. Though there were not multiple instances of each subsystem, allowing the harvester to transfer either into the boll buggy or module builders provided the same effect, requiring the HSS to differentiate among machines. The same hydraulic press used in lab testing of message-sending automation was again used to simulate the accumulation of cotton in the harvester's basket, with the inclinometer being rotated by hand to simulate the raising and lowering of the basket. The following tests were conducted using various harvest situations to determine whether the overall system worked correctly:

- Determining whether messages are automatically triggered.
- Determining whether RFID tag numbers are successfully retrieved from the RFID reader.
- Determining whether the wireless message is sent and the basket number is incremented according to the control logic.

All the aforementioned tests were conducted simultaneously to ensure that all WMTS components worked together and did not interfere with each other. All simulated transfers took place between harvester and boll buggy or harvester and module builders. The hydraulic press was mounted in the harvester to simulate accumulation of weight upon the load cell loads in the field. Four types of cotton transfer were conducted in random order. The first partial transfer involved loading the load cells to 3,600 kg (8,000 lbs) (full basket) and then decreasing the load by 15%. Based on the control logic employed, a decrease of this amount should result in a 'NO DUMP' call, thus no change in basket number and no wireless message sent. Following this, the remainder of the load was removed, which should result in a 'FULL DUMP' call, and the basket number should increase and a wireless message should be sent. The second partial transfer was done similarly to the first, but the initial transfer reduced the load by 50%. This decrease should result in a ’PARTIAL DUMP’ call, which should not increase the basket number but should send a wireless message. The remainder of the load was then removed, which again should result in the sending of a wireless message and an increase in basket number. For the third partial transfer, 85% of the full load was removed from the load cells, which decrease should result in a 'FULL DUMP' call and an increase in basket number. The complete transfers were simulated similarly to the partial transfers, but the entire load was removed each time. The harvester simulated transferring cotton to each of the three other harvest vehicles, as described in the previous paragraph, five times (Table 5).

Table 5. Simulated harvester transfer types

Simulation	**Receiver**	**Dump Type**
1	B1	Complete
2	B1	Complete
3	B1	Partial (85%)
4	B1	Complete
5	B1	Partial (15%)
1	M1	Partial (50%)
2	M1	Partial (50%)
3	M1	Complete
4	M1	Partial (15%)
5	M1	Complete
1	M2	Complete
2	M2	Partial (85%)
3	M2	Complete
4	M2	Complete
5	M2	Partial (50%)

Automatic Triggering

Automatic triggering of the wireless message was confirmed by observing the displays of the HSS, BBSS, and MBSS and verifying that a message was sent when it should have been sent and that the basket number changed when it should have changed. The wireless messages that are sent automatically appear in the 'Wireless Message' textbox on the HSS, while the basket numbers received by the BBSS or MBSS are displayed there also, making visual observation simple.

RFID Tag Number Retrieval

During the test of RFID tag number retrieval, surrounding non-receiving vehicles were kept at least 10 m (32.8 ft) away from the vehicles involved in the cotton transfer. When observing the HSS information window within the WMTS, the RFID tag number retrieved by the WMTS is displayed when a cotton transfer is simulated. Therefore, each tag number and each corresponding vehicle identified by the WMTS were recorded to ensure that the tag number was read properly and that the reported vehicle matched the tag number.

Control Action

The WMTS was monitored while cotton transfers were occurring to ensure that correct control decisions were made by the WMTS as appropriate for readings of the load cells, inclinometer, and RFID system. This testing was intended to verify that the system sent a wireless message when necessary and did not send a wireless message when not necessary. During this testing, the MBSS was the receiving vehicle part of the time, and the BBSS was the receiving vehicle part of the time. Whichever vehicle was not the receiving vehicle was placed 10 to 50 m (33 to 164 ft) away from the location of the cotton transfer to simulate the driving around of various vehicles in the field and the unpredictability of their locations. Observing the MBSS and the BBSS when a wireless message was sent enabled verification of whether the correct subsystem received the message.

RESULTS

OBJECTIVE 1

IMPACT Center

The output voltages of the inclinometer and load cell sensors (Figure 24) were recorded in a pretest immediately after the WMTS was installed on the John Deere 9965 harvester used at the IMPACT Center, prior to harvesting any cotton.

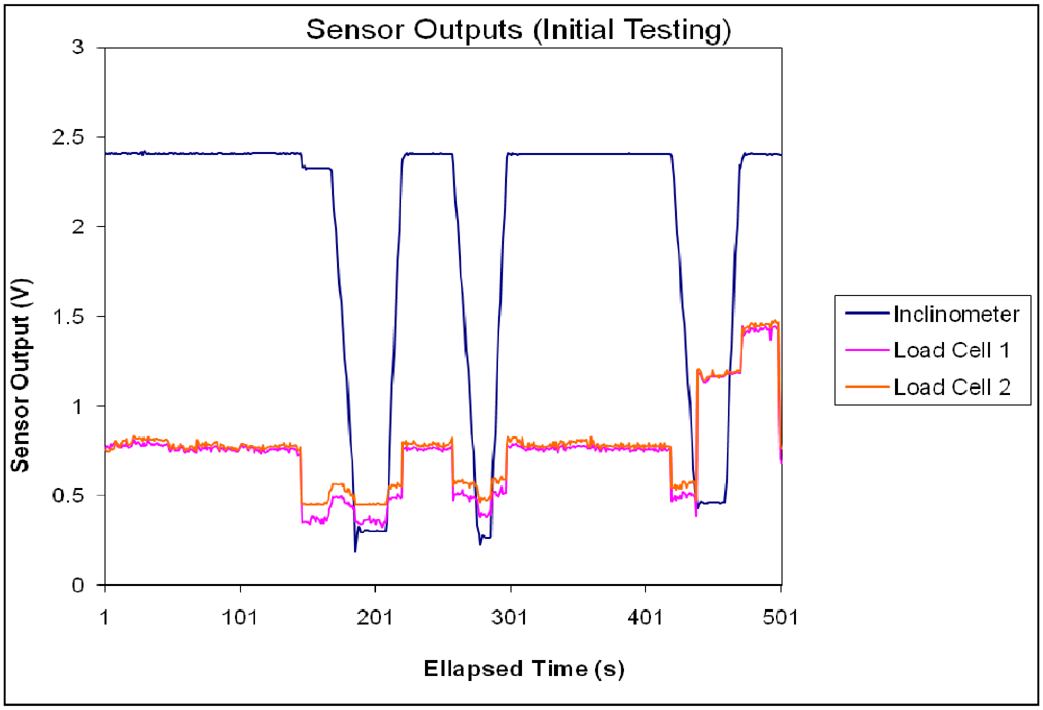


Figure 24. Load cell and inclinometer output data (initial testing)

Voltage dips and spikes from the inclinometer and the load cells correlated to each other correctly, in that when the inclinometer voltage began to decrease the load cell voltages simultaneously decreased. The decrease in voltage for the inclinometer indicated that the inclinometer was rotating in association with raising the harvester basket, while the decrease in voltage for the load cells indicated that weight on the load cells had been removed.

The field testing of the automated WMTS during the 2008 cotton harvest season at Texas A&M's IMPACT Center was partially successful. Yield data were collected for most of the field (Figure 25), and a module boundary map was made. It is visible from the yield map that only part of the field was irrigated by a center-pivot system. A portion of the yield map could not be produced, because at the beginning of harvest the yield sensors had been connected incorrectly to the data acquisition system. As a result, the inclinometer and load cells had also been connected incorrectly. By the time the problem was detected the harvester had already completed multiple dumps. Thus, only the collected GPS data were valid, and notes taken during the harvest had to be used to fill in this missing data for the module boundary map.

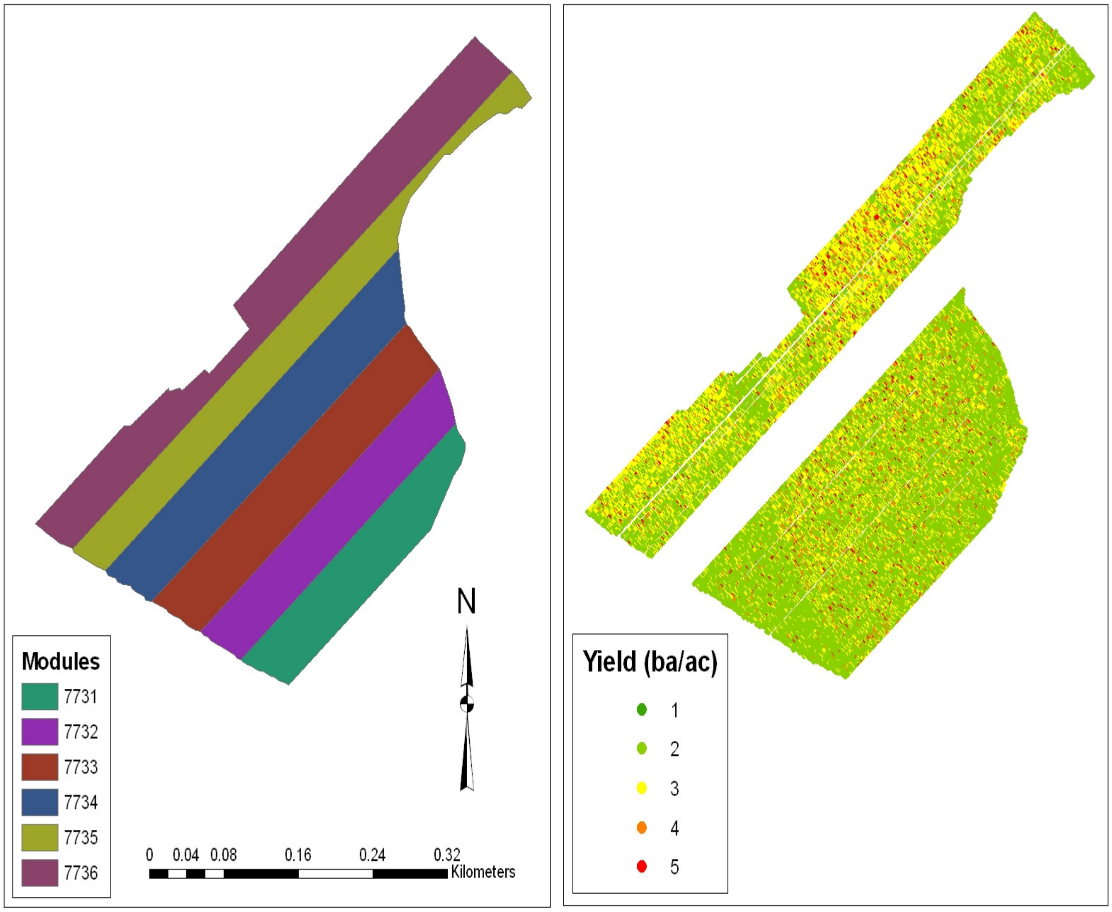


Figure 25. Module boundary and yield map of IMPACT Center

Module-level fiber-quality maps were also produced (Figure 26) after module averages of several fiber-quality parameters were applied back to the module-boundary map. These fiber-quality maps show how the different cotton properties changed as the harvester traversed the field. For instance, it is clear that the strength in the middle of the field is higher than the strength on either edge of the field. The values used for the fiber quality properties were taken from the Commodity Credit Corporation (CCC) Loan Schedule for 2008 (NCC, 2009). Values that would give producers premiums are displayed in green while those values that result in discounts are indicated by red and orange. Module average data for the IMPACT Center and Lubbock are recorded in full in Appendix C.

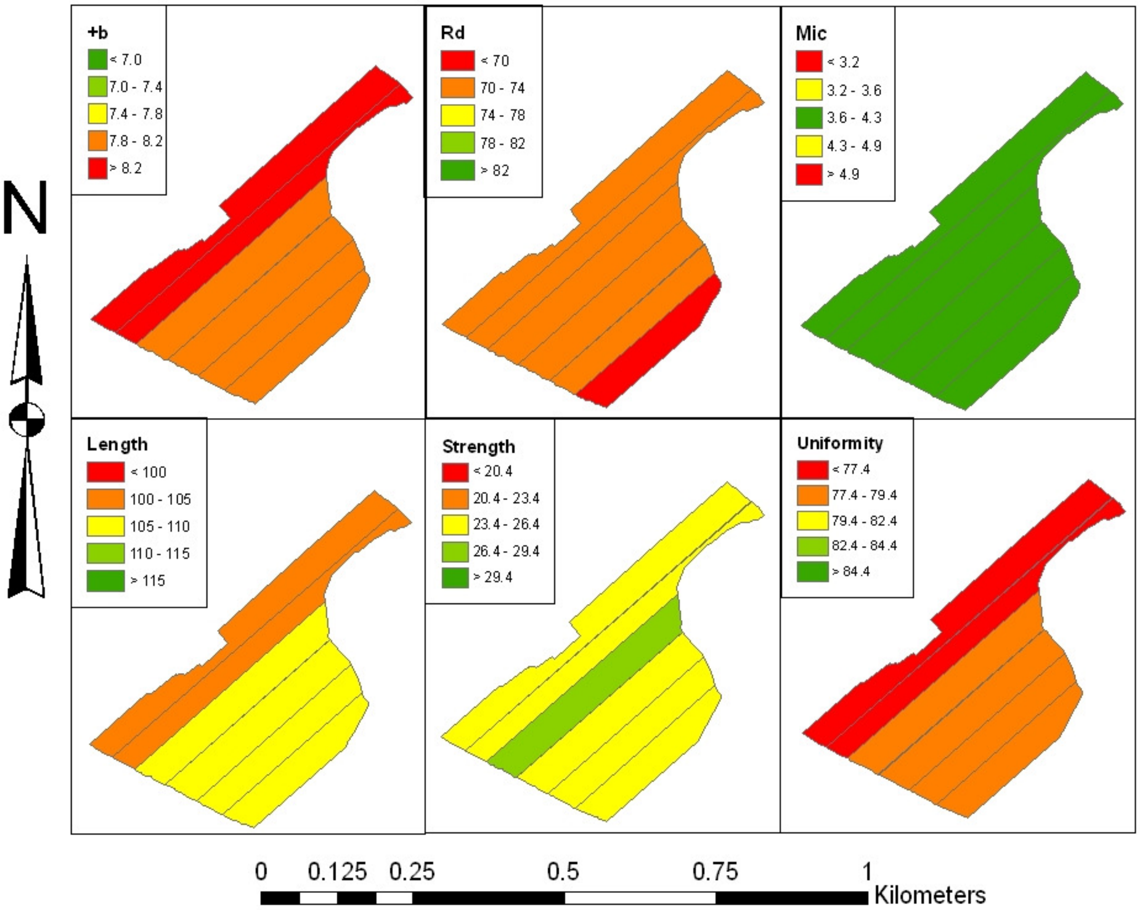
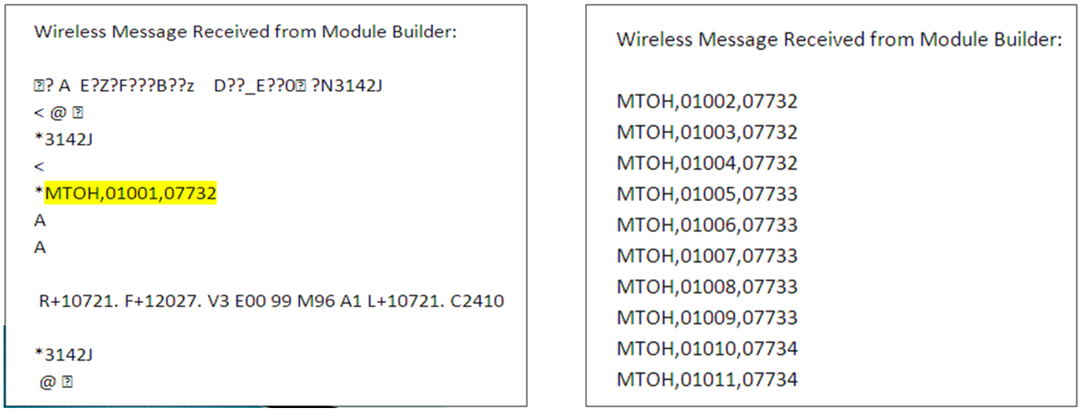


Figure 26. Module fiber-quality maps at the IMPACT Center

While useful maps were made, two problems surfaced during field testing of the automated WMTS near College Station. The first was interference from other wireless devices. A fellow researcher happened to be testing an automated module builder system that transmitted information from a computer through a separate wireless transceiver to controls within the module builder cab. These signals were picked up by the WMTS's wireless transceiver, and the data acquisition system embedded the extraneous signals in the collected data messages. Figure 27 shows a series of wireless messages and signals received by the transceiver as well as how the signals should have appeared.



Received Message

```
Wireless Message Received from Module Builder:

⍰? A  E?Z?F???B??z    D??_E??0⍰ ?N3142J
< @ ⍰
*3142J
<
*MTOH,01001,07732
A
A

 R+10721. F+12027. V3 E00 99 M96 A1 L+10721. C2410

*3142J
 @ ⍰
```

Expected Message

```
Wireless Message Received from Module Builder:

MTOH,01002,07732
MTOH,01003,07732
MTOH,01004,07732
MTOH,01005,07733
MTOH,01006,07733
MTOH,01007,07733
MTOH,01008,07733
MTOH,01009,07733
MTOH,01010,07734
MTOH,01011,07734
```

Figure 27. Received and expected wireless messages

This problem with extraneous signals was not insurmountable since the messages sent by the WMTS's MBSS were still recognizable (highlighted in Figure 27), but the extraneous messages did affect how the WMTS's post-processor functions. The post-processor reviews the wireless-message text file, looking for a specific format. When the post-processor comes across something in a different format, the sequence is aborted. For purposes of producing maps for this test, the extraneous signals were removed through manual post-processing of the data.

The more difficult problem was that, while the inclinometer functioned as designed and initiated triggering of wireless messages, the load cells did not work properly. Because of looseness in the basket (i.e., looseness) relative to the rest of the cotton picker, the contact points attached to the bottom of the cotton picker basket regularly slid off the load cells as the harvester moved throughout the field. Thus the load cells did not produce meaningful output values, and high amounts of stress were placed on the load cell mounting hardware. In Figure 28 it can be seen that when the inclinometer voltage varied strongly in association with a basket dump, the load cell voltage did not experience a change as it should have (recall Figure 24, produced from initial tests).

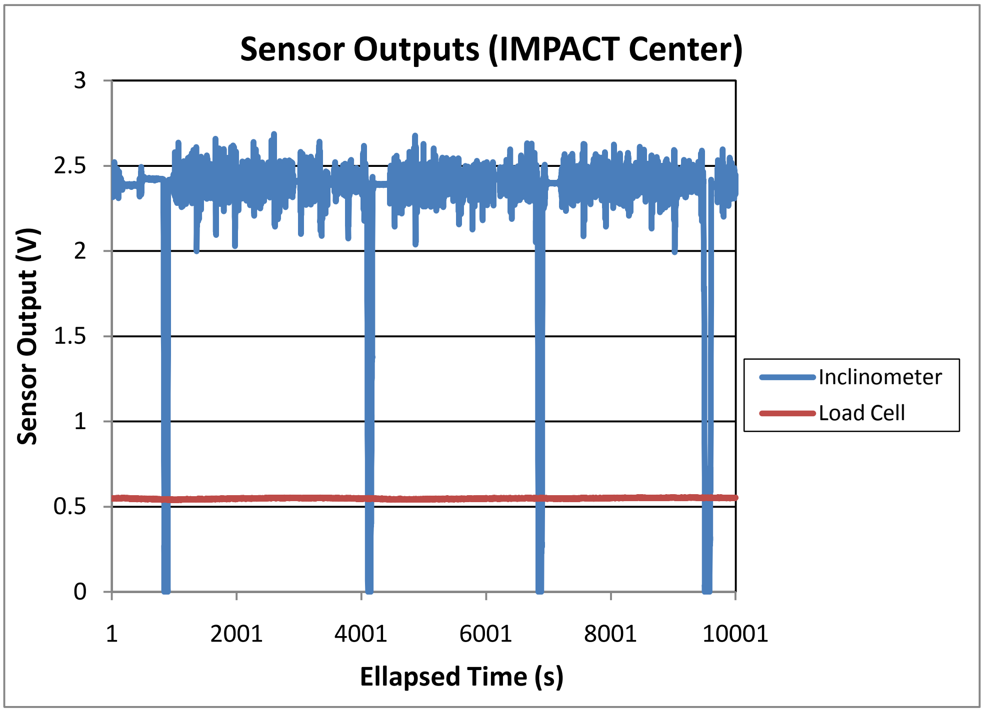


Figure 28. Field testing (IMPACT Center) inclinometer and load cell output data

Problems associated with the harvest at the IMPACT Center near College Station, TX were addressed porior to the start of harvest in Lubbock, TX.

Lubbock

The new load cell assembly was welded to the harvester's basket support beam, subjecting the load cells to high temperatures and causing them to lose calibration and yield incorrect voltage readings. For the first portion of the harvest in Lubbock, harvesting had to proceed before recalibration could be performed, so no useful load cell data were gathered, as had happened at the IMPACT Center, and as can be seen in the sensor outputs in Figure 29. Nevertheless, the modified WMTS program with wireless message filtering worked as designed, and only messages sent by WMTS subsystems were recorded.

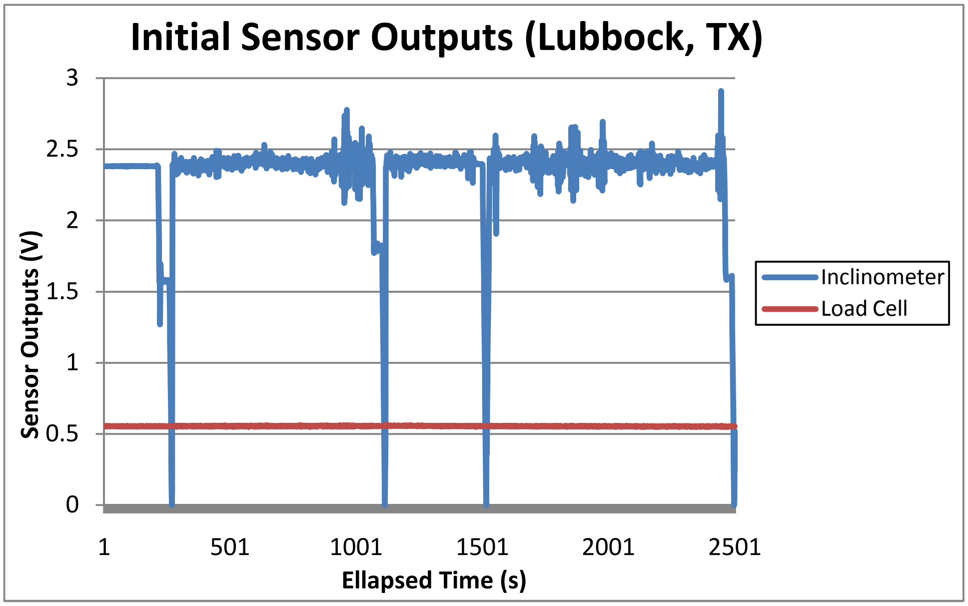


Figure 29. Initial sensor outputs from Lubbock field tests

In the final portion of the harvest in Lubbock, before which the load cells had been recalibrated, the entire system worked as designed, with no interference from surrounding wireless devices, and the load cells operating correctly. Figure 30 shows the sensor outputs from one of the final testing days in Lubbock, and it is clear that the load cells measured the accumulating weight.

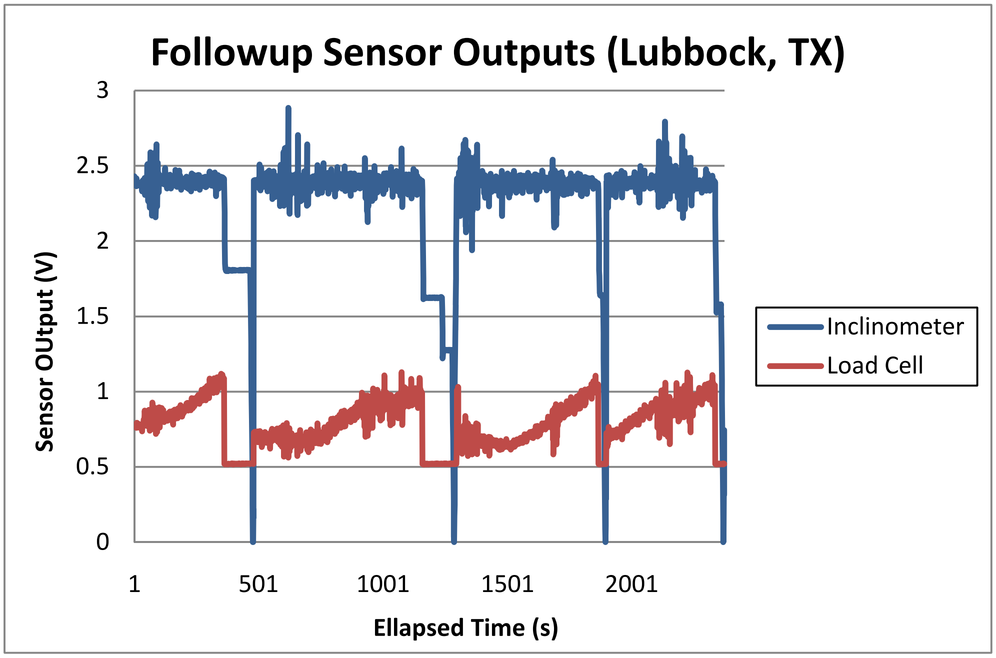


Figure 30. Field testing (Lubbock) inclinometer and load cell output data

The large dips in the inclinometer line in Figures 24, 28, and 29 represent the raising of the basket. The load cell line in Figure 30 gradually increases, meaning that cotton is entering the basket, and then decreases sharply at the same point the inclinometer does. This decrease in the load cell line occurred because the load cells were no longer supporting the basket when it was raised. Though both the load-cell and inclinometer signals seem to have a significant level of noise associated with them, the accuracy of the sensors appears to be very acceptable for the purpose of automating the triggering of wireless messages. Appendix D contains raw data from two baskets loads displayed in Figure 30. This is true because the information drawn from the sensors needs only to represent major changes so that a discrete decision (send message, or do not send message) can be made.

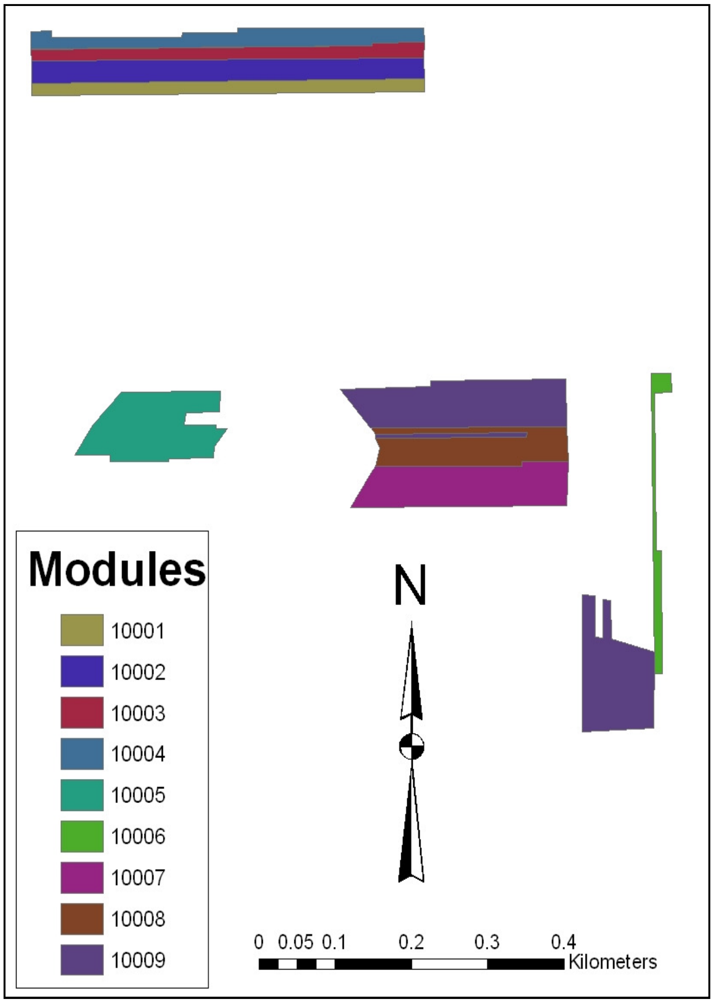


Figure 31. Module boundary map (Lubbock)

Figure 31 is the module boundary map produced from the data gathered during tests in Lubbock. The data used to create the map (sensor, basket, and module information) were collected automatically by the WMTS. No yield map was produced for the tests in Lubbock as per the request of the cooperating producer.

The fiber-quality maps produced from the gathered data in Lubbock are shown in Figure 32. These fiber quality maps reveal that the uniformity of the cotton does not vary much throughout the field; however, the yellowness (+b) of the cotton varies highly from module to module.

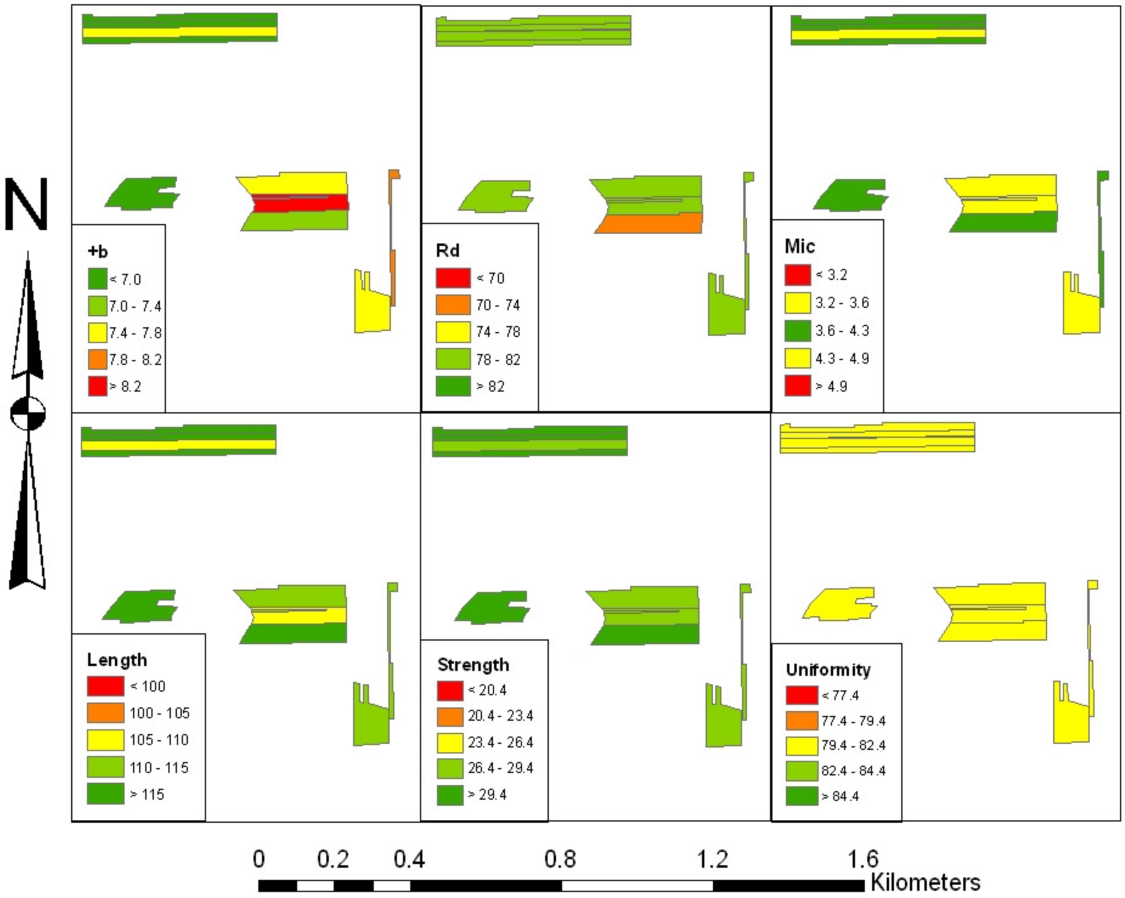


Figure 32. Fiber-quality maps from Lubbock, TX field tests

OBJECTIVE 2

Preliminary testing of the RFID system yielded promising results. Some problems were discovered, but design modifications enabled the RFID-incorporated WMTS to be a robust system.

Data from one testing run associated with RFID question 1 (How should the reader and tag be oriented on the harvesting vehicles to optimize their performance?) are displayed in Table 6. Three other testing runs yielded similar results, indicating that this is a representative set of data. Tag positions in the table are taken from Figure 22.

Table 6. Question 1a testing results

Tag Position	**Tag Read**	**Notes**
1	Y	
2	Y	
3	Y	
4	Y	
5	Y	
6	Y*	at eye Level (no obstructions)
7	N	
8	N	
9	N	
10	Y*	at eye Level (no obstructions)

Positions 1 thru 5 (all forward positions) were all detected by the RFID reader at distance of 10 m and height of 0.61 m. At positions 6 and 10 (slightly rearward positions), when the RFID tag was raised to a height of 1.83 m (6 ft) the reader detected it. Detection at this level was apparently because the tag had been raised above the bed and hood height of the truck used in the test, which was 1.22 m (4 ft), allowing for a line of sight between the reader and tag. Since harvesting equipment is larger than the truck used in the test, and since the mounting location of the RFID tags will typically be closer to the ground, detecting tags that are positioned slightly behind the RFID reader (positions 6 and 10) should not be a problem. Positions 7 thru 9 (all rearward positions) were not detected by the reader to a level of 2.44 m (8 ft) above the ground. Thus, the reader basically did not detect any of the tags on the non-dumping side of the dumping vehicle, tags which represented potential non-receiving vehicles. In addition to the fact that the RFID reader's signals tend to be emitted in only one hemisphere, it also seems that the dumping vehicle acts as a transmission obstacle. The fact that the reader detected tags at positions 6 and 10 only when a line of sight was available indicated that the reader's signals were apparently blocked by the vehicle, further reducing the chance that the reader would detect tags not on the dumping side of the vehicle. These results indicate that the scanning direction of the RFID reader can be limited mainly to the dumping side of the harvester or boll buggy. Moreover, when an additional RFID tag was introduced into the scenario the RFID reader detected the closest tag most often. Table 7 shows some (for when the receiving tag was in position 3, the primary receiving position) results from the testing with multiple RFID tags.

Table 7. Question 1b testing results

NR Tag position	NR Tag Distance	NR Tag Read	Notes
1	7 m	NO*	NR detected but not a majority
2	10 m	NO	
3	10 m	NO	
4	5 m	YES*	
5	10 m	NO	
6	7 m	NO*	NR detected but not a majority
7	5 m	NO	
8	5 m	NO	
9	5 m	NO	
10	7 m	NO*	NR detected but not a majority

NR is non-receiving

From Table 7 it can be seen that the non-receiving tag was detected in this scenario multiple times. With the non-receiving tag positioned at 7 m or less away, it was detected by the RFID reader; however, the receiving tag (which was closer) was detected the majority of the time. When the non-receiving tag was placed at position 4, it was detected the same number of times as the receiving tag due to their being the same distance away from the reader. This situation should never occur within the field; however, because multiple receiving vehicles could not be in such a small area at the same time due to their size.

Results from testing associated with RFID question 2 (Do transmissions from the RFID reader or tag interfere with the wireless transceiver within the system or vice versa?) revealed that the current software data filters are adequate to prevent the wireless transceiver from picking up RFID signals. The results from a single test of four different scenarios are shown in Table 8.

Table 8. Question 2 testing results

Test	RFID Reader Status	Wireless Transceiver Status	RFID Tag Present	RFID Reader Output	Wireless Transceiver Output
1	Scanning	Listening	No	NONE	NONE
2	Scanning	Listening	Yes	RFID Tag number	NONE
3	Scanning	Sending Message	No	NONE	Wireless Message
4	Scanning	Sending Message	Yes	RFID Tag number	Wireless Message

When the transceiver was in listening mode and the RFID reader was in active-scanning mode, no RFID signals were picked up by the transceiver, regardless of whether an RFID tag was present. Furthermore, the RFID reader picked up no signals from the wireless transceiver while it transmitted wireless messages. The only signals detected by the RFID reader and the wireless transceiver were those designated for the particular device; i.e., the RFID reader detected a tag when one was present, and the wireless transceiver detected the wireless message sent to it. These results were further verified in three subsequent tests when, again, no extraneous signals were detected by either device.

Post-design testing proved that incorporation of the RFID system into the WMTS was successful, but subsequent minor software modifications were required. The answer to RFID question 3 (Does the RFID system repeatedly differentiate among the various harvesting machines?) was affirmative. The results shown in Table 9 are from a single scanning session when tag M1 was closest to the RFID reader. When two or more RFID tags were near an RFID reader, all the tags could potentially have been detected, but the closest tag was detected most often by the reader. In this situation the tag M1 was chosen correctly as the receiving vehicle.

Table 9. Question 3 testing results

Scan Number	Tags Detected
1	M1
2	M1, B1
3	M1
4	M1
5	M1, B1

The results of the single scanning situation mentioned above were consistently true for five different scanning situations. The distance between the non-receiving tag and the reader, relative to the distance between the receiving tag and the reader, determined how many times the non-receiving tag was detected. If the non-receiving tag were farther away from the reader than in the example of Table 9, it would have been detected less often, while if it were closer it would have been detected more often. In summary, the closer tag (receiving tag) was always detected more often. On the other hand, when the RFID system was tested with multiple RFID tags present, the RFID reader required a minimum amount of time to reset before accurately scanning again. Thus, in the beginning the reader initially would continue to detect the tag first placed in the position of the receiving machine even after a new tag had been placed in the position of the receiving machine. The additional time-delay code allowed the RFID reader to fully reset itself, and after incorporating this minor software modification, the WMTS was tested again and the problem was no longer present.

Finally, testing associated with RFID question 4 (Will RFID tags on other receiving vehicles interfere with the RFID tag on the receiving vehicle involved in the current cotton transfer?) indicated the following (Table 10): (a) when the non-receiving vehicle was revolving clockwise around the transferring vehicles, its RFID tag was not detected at any of the four positions tested; (b) while stationary, the non-receiving vehicle's tag was not detected when facing away from the transferring vehicles cotton in any tested position; (c) the direction the non-receiving tag was facing made no difference at positions 2 and 4, apparently because the transferring vehicles blocked the signal from reaching the non-receiving tag; and (d) at positions 1 and 3 the non-receiving tag was occasionally detected by the RFID reader when the tag faced toward the transferring vehicles, regardless of whether the non-receiving vehicle was moving or stationary. With respect to point (d), during the second scanning event at position 3 the WMTS incorrectly identified the receiving vehicle. This error could not be reproduced, and the five follow up tests all resulted in the correct receiving vehicle being identified.

Table 10. Question 4 testing results

Position	Rotation	Status	Read non-receiving?	Notes
1	clockwise	stationary	NO	
2	clockwise	stationary	NO	
3	clockwise	stationary	NO	
4	clockwise	stationary	NO	
1	counter	stationary	NO*	Was detected but not the majority
2	counter	stationary	NO	
3	counter	stationary	NO**	Was detected but not the majority Initially non-receiving tag was incorrectly detected
4	counter	stationary	NO	
1	clockwise	moving	NO	
2	clockwise	moving	NO	
3	clockwise	moving	NO	
4	clockwise	moving	NO	
1	counter	moving	NO*	Was detected but not the majority
2	counter	moving	NO	
3	counter	moving	NO*	Was detected but not the majority
4	counter	moving	NO	

Even though the non-receiving tag was occasionally detected at positions 1 and 3, of the six different scanning events at each position it was only chosen as the majority of scans one time. Thus, the actual receiving tag was selected by the WMTS as representing the receiving vehicle in almost every test, and the wireless message was sent to the correct vehicle in these cases. Based on points (a) through (d) above, it is clear that the non-receiving vehicle's tag was more likely to be detected when the vehicle was stationary and when its tag was facing the transferring vehicles, but even then the system largely worked as designed.

OVERALL TESTING

Overall testing of the WMTS was partially successful, and the incorporated sensors and RFID system were typically able to correctly indentify when cotton was removed from the basket and which vehicle was receiving cotton. The automatic triggering to send the wireless message – which was attempted first – worked for the first simulated basket of cotton. When the inclinometer's voltage exceeded the preset threshold, the WMTS was informed that the harvester basket was being raised, and it initiated the RFID procedure to determine to which vehicle the cotton was being transferred. After the harvester basket was lowered back to the seated position the load cell readings were used to determine whether a partial, complete, or no dump had occurred. Based on this information the compiled wireless message was sent to the receiving harvest vehicle's subsystem (MBSS 1), which correctly displayed the basket number of the transferred cotton. Upon receiving the wireless message, the MBSS then sent a reply message to the HSS, which again displayed the correct message with basket and corresponding module information. Initially, the remaining simulated cotton transfers, however, were not successful as the WMTS was not informed that a cotton transfer had occurred. In these latter cases the HSS did not write a wireless message, and the RFID reader thus did not scan for a receiving vehicle, indicating an error within the software. Therefore, to complete initial overall system tests, manual triggering was subsequently used. The manual trigger algorithm only worked for complete cotton transfers and did not take into account load cell readings. Each time a complete cotton transfer was simulated in this way, the HSS incremented the basket number after sending a wireless message. Following this testing the software was revised as previously mentioned in the overall testing methods and the remaining tests for partial cotton transfers were conducted with automatic triggering. Table 11 reveals the actions taken by the WMTS from the simulated partial and full dumps. All simulated dump results were visually verified by observing the output on the corresponding subsystem.

Table 11. Simulated harvester transfer results

Simulation	Receiver	Dump Type (remaining cotton)	Basket Increase?	Message Sent?	Correct Action?	Notes
1	B1	Complete	YES	FULL DUMP	YES	
2	B1	Complete	YES	FULL DUMP	YES	
3	B1	Partial (85%)	NO	PARTIAL DUMP	NO	Should have been FULL DUMP and Basket + 1
4	B1	Complete	YES	FULL DUMP	YES	
5	B1	Partial (15%)	NO	NO DUMP	YES	
1	M1	Partial (50%)	NO	PARTIAL DUMP	YES	
2	M1	Partial (50%)	NO	PARTIAL DUMP	YES	
3	M1	Complete	YES	FULL DUMP	YES	
4	M1	Partial (15%)	NO	PARTIAL DUMP	NO	Should have been NO DUMP
5	M1	Complete	YES	FULL DUMP	YES	
1	M2	Complete	YES	FULL DUMP	YES	
2	M2	Partial (85%)	YES	FULL DUMP	YES	
3	M2	Complete	YES	FULL DUMP	YES	
4	M2	Complete	YES	FULL DUMP	YES	
5	M2	Partial (50%)	NO	PARTIAL DUMP	YES	

For all complete dumps simulated, the WMTS automatically and correctly sent out a wireless message to the receiving subsystem and incremented the basket number. When a significant percentage of the cotton was removed from the basket (20% - 80%) the WMTS, again correctly, sent out the wireless message and did not increment the basket number. However, when the percentage of cotton removed from the basket was very close to 15% or 85%, small errors in the load cell readings around these decision boundaries sometimes caused the WMTS to take an unexpected action. This situation occurred because it was difficult to provide a precisely accurate load-cell-input value when using the hydraulic press to simulate basket loads. For example, with load-cell-input values slightly higher than 15% the WMTS would not send the wireless message if the load-cell-output value read by the WMTS was slightly lower than 15%; while for load-cell-input values slightly lower than 85% the WMTS would increment the basket number if the load-cell-output value read by the WMTS was slightly higher than 85%. Similarly, when the percentage of cotton removed was supposed to be slightly lower than 15% (when a ”NO DUMP” call should have been made), the WMTS sometimes incorrectly sent out the wireless message because of the imprecise input value. The same was also true for percentages of cotton removed slightly higher than 85% (when a “FULL DUMP” call should have been made, with the WMTS incrementing the basket number), for which the WMTS sometimes incorrectly did not increment the basket number because of the imprecise input value. After reviewing the actual load-cell data read by the WMTS during the overall testing, it was determined that in fact the WMTS had always made the correct decision as specified by the system design. For example, a simulated partial cotton transfer was supposed to remove 15% of the cotton; however, the amount the WMTS read as removed based on the load-cell outputs was closer to 26%. This ultimately resulted in the WMTS’s indicating that a “PARTIAL DUMP” had occurred, which was an unexpected, but correct result. A complete set of simulated data for a single module (7 baskets) can be seen in its entirety in Appendix E.

CONCLUSIONS

OBJECTIVE 1

A suite of sensors (inclinometer and load cells) was incorporated into an automated control system to achieve the first objective of this research: automating the wireless message triggering of the wireless module-tracking system (WMTS) to eliminate the system's dependence on a vehicle operator and reduce the chance of errors. Tests were conducted in two locations (near College Station, TX and Lubbock, TX) during the 2008 cotton harvest to verify the reliability of the automated WMTS. Following testing-based design improvements, the final test in Lubbock, TX proved that the sensor-based wireless-message triggering worked according to design. Cotton fiber quality maps were successfully made based on module tracking done by the automated system.

OBJECTIVE 2

A radio-frequency identification (RFID) system was incorporated into the WMTS to achieve the second objective of this research: enabling the WMTS to distinguish among the various harvesting machines, a requirement for applying the WMTS in large scale operations such as farms using multiple harvesters, boll buggies, or module builders. Testing in substitute vehicles on the campus of Texas A&M University verified that the incorporation of the RFID system into the WMTS worked according to design. The WMTS successfully distinguished among harvest machines and sent wireless messages to the correct machines.

OVERALL TESTING

The sensor-based automation system and the RFID system were incorporated into the WMTS and tested together for overall system testing. When complete dumps were simulated, the WMTS made the correct decisions 100% of the time. Partial dump simulations resulted in what originally appeared as incorrect decisions by the WMTS 25% of the time when the remaining cotton percentage in the basket was near the decision boundaries (15% between no dump and partial dump and 85% between partial dump and full dump). However, the WMTS was making the correct decisions, but the load cell readings were not being accurately simulated such that the WMTS could carry out the expected action. In all cases the RFID system identified the correct receiving machine, enabling direct machine-to-machine communication. Thus the overall testing was successful.

DISCUSSION AND RECOMMENDATIONS

POTENTIAL APPLICATIONS

The WMTS will enable producers to improve profit by managing their cotton crop not only for yield, but also for fiber quality. By combining fiber quality and yield maps from the same field, a producer can also create a revenue map indicating the variability of revenue across the field, and coupled with input-cost maps profit can also be mapped. There are many ways that producers may use profit maps to improve their operations' bottom lines. One example can be considered in association with Figure 25. It is clear from the figure that the IMPACT Center (near College Station, TX) field during 2008 had higher yield underneath the center pivot irrigation system, particularly in the north-central area of the field. Similarly, in this same area in Figure 26 (fiber quality maps) there is low strength and length. One option a producer might consider in this area of the field is to allow the cotton to mature longer than in other areas, so as to produce stronger and longer fibers. Another possibility exists in this same field. The cotton had good micronaire across the field (Figure 26) but was not high yielding. Since micronaire has a large impact on the price of cotton, it might be worthwhile for the producer to plant cotton only where it will be irrigated by the center pivot. Doing so would give the producer a higher average yield while at the same time decreasing input costs, resulting in higher revenue. The remaining portions of the field could conceivably be placed in the Conservation Reserve Program. Another possibility currently under study is to vary the seeding rate based on the variability of soils, yield, and fiber quality.

ISSUES REGARDING USE OF THE SYSTEM

The Lubbock, TX producer's fields shown in Figure 31 were positioned around fields of other crops and other producer's fields. Having these large areas between modules makes it difficult to accurately decide on site specific crop management practices to use. For this reason a producer should keep the area from which a single module is created small to maximize the benefit from the WMTS. For instance, four modules are created entirely from cotton in the northern field. By producing at least four modules from this area the producer can notice changes in fiber quality and utilize proper practices to maximize their quality from this field. If the producer were to create fewer cotton modules in this area of the field, there might not be enough variation to recognize specific field locations that need to be addressed.

FUTURE RESEARCH

Though the current improvements to the WMTS have made it more user friendly and robust, to effectively market this system to farmers, a final capability is needed. Recently, talks have been held between Texas A&M University researchers and FarmWorks Corporation to integrate the WMTS with the FarmWorks software package. The concept in these discussions is to enable the WMTS to communicate directly with farmers' and consultants' office software and automate the production of profit maps. Eliminating the numerous steps that would be currently required to produce a profit map will make the WMTS easier to commercialize, because it will be easier to use, not forcing the farmer to learn to manipulate complicated software.

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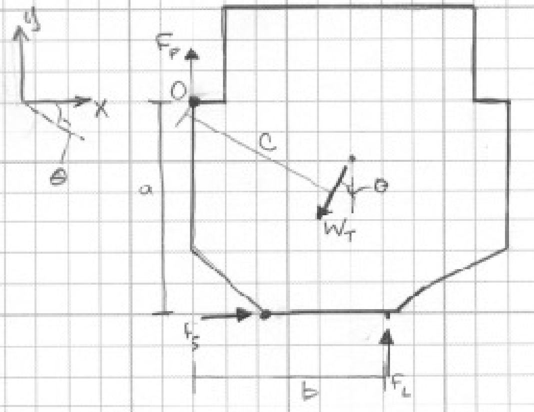
APPENDIX A

EQUATION DERIVATION

EQUATION DERIVATION 1/3

FBD HARVESTER BASKET



STATIC EQUILIBRIUM EQUATIONS

SUM OF FORCES IN X-DIRECTION

$$\Sigma F_x = 0 = F_S(\cos(0)) + F_L(\cos(90)) + W_T(\cos(270 - \theta)) + F_P(\cos(90))$$

SUM OF FORCES IN Y-DIRECTION

$$\Sigma F_y = 0 = F_S(\sin(0)) + F_L(\sin(90)) + W_T(\sin(270 - \theta)) + F_P(\sin(90))$$

SUM OF MOMENTS AT ORIGIN (POINT O)

$$\Sigma M_O = 0 = F_S(a) + F_L(b) - W_T(c) + F_P(0)$$

DERIVATION OF F_S EQUATION (FROM ΣF_x)

$$F_S(\cos(0)) + F_L\cancelto{0}{(\cos(90))} + W_T(\cos(270 - \theta)) + F_P\cancelto{0}{(\cos(90))} = 0$$

$$F_S(1) = -W_T(\cos(270 - \theta))$$

$$\boxed{F_S = -W_T(\cos(270 - \theta))}$$

DERIVATION OF F_L EQUATION (FROM ΣM_O)

$$F_S(a) + F_L(b) + \cancelto{0}{F_P(0)} - W_T(c) = 0$$

$$F_L(b) = W_T(c) - F_S(a)$$

$$F_L = \frac{(W_T(c) - F_S(a))}{b}$$

$$F_L = \frac{\left(W_T(c) - \left(-W_T(\cos(270-\theta))\right)(a)\right)}{b}$$

$$\boxed{F_L = \frac{W_T(c + a(\cos(270-\theta)))}{b}}$$

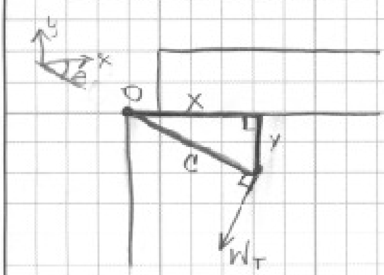
DERIVATION OF F_P EQUATION (FROM ΣF_y)

$$F_S\left(\overset{0}{\cancel{\sin}}(0)\right) + F_L(\sin(90)) + W_T(\sin(270-\theta)) + F_P(\sin(90)) = 0$$

$$F_P(1) = -\left(F_L(1) + W_T(\sin(270-\theta))\right)$$

$$\boxed{F_P = -\left(\frac{W_T(c + a(\cos(270-\theta)))}{b} + W_T(\sin(270-\theta))\right)}$$

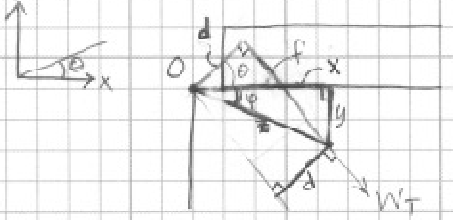
DERIVATION OF c EQUATION



$$x^2 + y^2 = c^2$$

$$\boxed{c = \sqrt{x^2 + y^2}}$$

DERIVATION OF d EQUATION (IF HARVESTER SLOPED OPPOSITE DIRECTION)



$$\tan(\varphi) = \frac{y}{x}$$

$$\varphi = \tan^{-1}\left(\frac{y}{x}\right)$$

3/

$$z^2 = y^2 + x^2$$

$$z = \sqrt{y^2 + x^2}$$

$$\sin(\theta + \varphi) = \frac{d}{z}$$

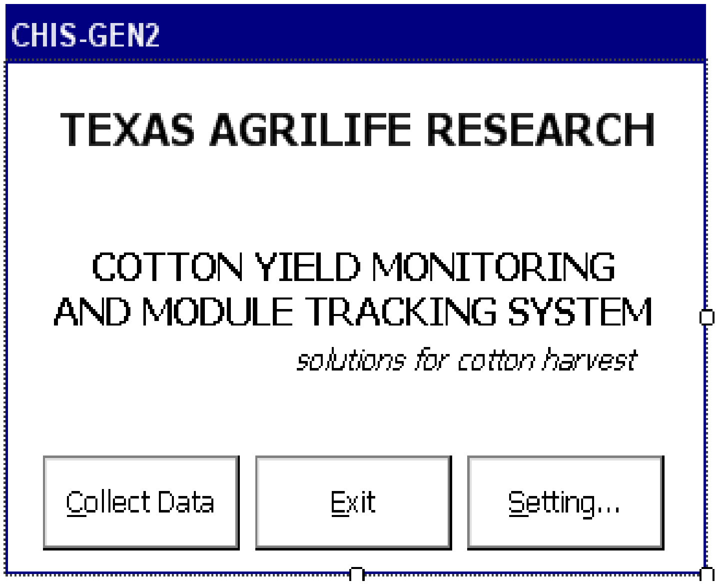
$$d = z(\sin(\theta + \varphi))$$

$$\boxed{d = \sqrt{y^2 + x^2}\left(\sin\left(\theta + \tan^{-1}\left(\frac{y}{x}\right)\right)\right)}$$

APPENDIX B

WMTS SOURCE CODE

MAIN FORM


CHIS-GEN2

TEXAS AGRILIFE RESEARCH

COTTON YIELD MONITORING
AND MODULE TRACKING SYSTEM

solutions for cotton harvest

Figure B-1. Main form display

```
Public Class frmMain

        'When the collect data button is selected , do the following and then go to the collect page
    Private Sub btnCollect_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles btnCollect.Click

        '-----------------------------------------------------------------------
        'open up serial ports 1, 2, and 3
        'Among which COM1(RS232) is connected to GPS, this is on the SBC main board
        'Among which COM3(RS485) is connected to wireless transceiver, this is on the GPIO daughter board
        'Among which COM2(RS232) on the SBC main board is connected to the RFID reader

        If frmCollect.SerialPort1.IsOpen Then
            frmCollect.SerialPort1.Close()
        End If
        'Try to open COM1 with the port settings "4800-N-8-1"
        Try
            With frmCollect.SerialPort1
                .BaudRate = 4800
                .Parity = IO.Ports.Parity.None
                .DataBits = 8
                .StopBits = IO.Ports.StopBits.One
            End With

                'Open serial port 1
            frmCollect.SerialPort1.Open()
```

```
    Catch ex As Exception

        'If serial port 1 cannot be opened then exit the program
        MsgBox("Cannot open COM1 on XScale, continue?", MsgBoxStyle.OkOnly)
      Application.Exit()
    End Try


        'IF serial port 2 is open then close it so the correct settings can be applied.
        If frmCollect.SerialPort2.IsOpen Then
      frmCollect.SerialPort2.Close()
    End If

    '------------------------------------------------------------------------

        'Try to open serial port 2 with these settings (9600-N-8-1)
Try
      With frmCollect.SerialPort2
        .BaudRate = 9600
        .Parity = IO.Ports.Parity.None
        .DataBits = 8
        .StopBits = IO.Ports.StopBits.One
      End With
      frmCollect.SerialPort2.Open()
   'If unable to open serial port 2 send error message
Catch ex As Exception

        'If serial port 2 cannot be opened then ask if user wants to continue anyways
        Dim _result2 As Boolean = MsgBox("Cannot Open COM2 on XScale, Continue?",
MsgBoxStyle.YesNo)

        'if not then exit application
        If _result2 = False Then
        Application.Exit()
      End If
    End Try

        'If serial port 3 is open thn close so proper port settings can be applied
    If frmCollect.SerialPort3.IsOpen Then
      frmCollect.SerialPort3.Close()
    End If

    'Try to open COM3 with setting "4800-N-8-1"
    'Note that this port is on the GPIO board but not the XScale main board
    Try
      With frmCollect.SerialPort3
        .BaudRate = 4800
        .Parity = IO.Ports.Parity.None
        .DataBits = 8
        .StopBits = IO.Ports.StopBits.One
      End With
      frmCollect.SerialPort3.Open()
```

```
        'Ask user if they want to continue if serial port 3 isn’t open
Catch ex As Exception
      Dim _result3 As Boolean = MsgBox("Cannot open COM3 on the GPIO board, continue?",
MsgBoxStyle.YesNo)

        'If not exit application
        If _result3 = False Then
        Application.Exit()
      End If
    End Try

    'Create datafile and write the file header

    Dim _tempdata As String
    Dim _tempmeta As String

    'Check if the directory "Storage Card\Data" exists
    'If not, create this directory
    If IO.Directory.Exists(_wd) = False Then
      Try
        IO.Directory.CreateDirectory(_wd)

'If unable to create directory give error message and close application
        Catch ex As Exception
        MsgBox("failed to create the data folder, restart program", MsgBoxStyle.OkOnly)
        Application.Exit()
      End Try
    End If

    'if current data is not to be appended to older file then
    If (_append = False) Then

        'Initially set data files to end witht the number 1
        Dim _filenum As Integer = 1
      _tempdata = _wd & "\data_" & CStr(_filenum) & ".txt"
      _tempmeta = _wd & "\metadata_" & CStr(_filenum) & ".txt"

        'If data files already exist ending with 1 then increase number until no data file with
matching number is found.
        Do While (IO.File.Exists(_tempdata) Or IO.File.Exists(_tempmeta)) = True
        _filenum = _filenum + 1
        _tempdata = _wd & "\data_" & CStr(_filenum) & ".txt"
        _tempmeta = _wd & "\metadata_" & CStr(_filenum) & ".txt"
      Loop

      'File Operations (creating new files)

      _datafilename = _tempdata
      _metadatafilename = _tempmeta
      _rawdata = IO.File.CreateText(_datafilename)
      _metadata = IO.File.CreateText(_metadatafilename)
```

```
         'Inserting header into new file, gives all information about time and numbers of harvesting
equipment.
         _rawdata.WriteLine("Longitude,Latitude,Speed,PDOP,YldS1,YldS2,LC1,LC2,Incl,Basket,Dump
Triggerred,Dump Type")
         _metadata.WriteLine("Harvest Start Time: " & CStr(Now()))
         _metadata.WriteLine("Header Width: " & CStr(_HeaderWidth))
         _metadata.WriteLine("Row Space: " & CStr(_RowSpace))
         _metadata.WriteLine("Number of Boll Buggies: " & CStr(_BBNum))
         _metadata.WriteLine("Number of Module Builders: " & CStr(_MBNum))
         _BsktNum = 1 'New harvest, the current basketnumber is set to 1

' File needs to be close and reopen periodically to make sure data points are ‘collected and stored
         _rawdata.Close()
         _metadata.Close()

         _rawdata = IO.File.AppendText(_datafilename)
         _metadata = IO.File.AppendText(_metadatafilename)

         'currently these codes haven't been activated

'When returning to a harvest a producer wants to append to an existing file
      ElseIf (_append = True) Then

            'Find the file the producer wants to append
         _datafilename = "\Storage Card\Data\data_" & CStr(frmSetting.CmbFile.Text) & ".txt"
         _metadatafilename = "\Storage Card\Data\metadata_" & CStr(frmSetting.CmbFile.Text) &
".txt"
         _rawdata = IO.File.AppendText(_datafilename)
         _metadata = IO.File.AppendText(_metadatafilename)
         'Do I need to move the pointer to the very end of the file?
      End If

'If autotrigger is false the show the manual dump button
      If (_AutoTrigger = False) Then
         frmCollect.btnDump.Visible = True

            'Otherwise do not show the manual dump button
      Else
         frmCollect.btnDump.Visible = False
      End If

            'Start timer 1 on the collect form
      frmCollect.Timer1.Enabled = True
      Me.Hide()
      frmCollect.ShowDialog()
   End Sub

            'When settings button is selected, go to the settings page
   Private Sub btnSet_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles
btnSet.Click
      frmSetting.ShowDialog()
```

```
    End Sub

            'When exit button is selected, exit the program
    Private Sub btnExit_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles
btnExit.Click
        Application.Exit()
    End Sub

End Class
```

SETTINGS FORM

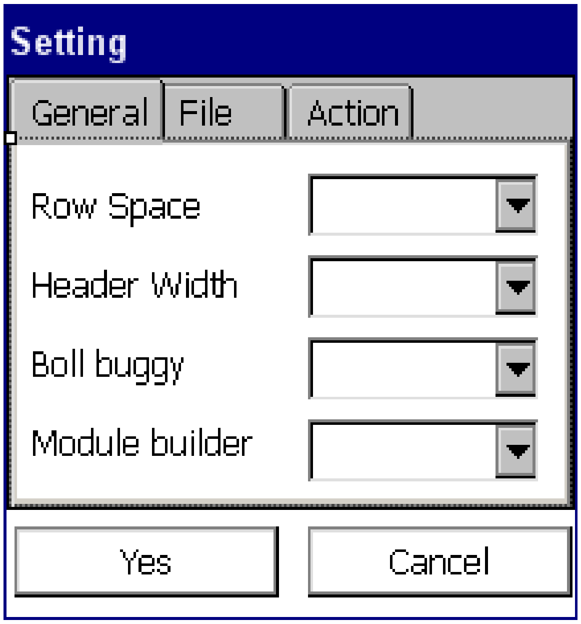


Figure B-2. Settings form display

```
Public Class frmSetting

  Private Sub frmSetting_Load(ByVal sender As Object, ByVal e As System.EventArgs) Handles
MyBase.Load

    'Items within the drop down menus

        'These specify the row spacing of the planted cotton
    CmbRow.Items.Add("15")
    CmbRow.Items.Add("30")
    CmbRow.Items.Add("36")
    CmbRow.Items.Add("40")
    CmbRow.Text = 40

        'This indicates the number of headers on the harvester
    CmbHeader.Items.Add("2")
    CmbHeader.Items.Add("4")
    CmbHeader.Items.Add("6")
    CmbHeader.Text = 6

        'This indicates the number of boll buggies to be used in the harvest
    CmbBB.Items.Add("1")
    CmbBB.Items.Add("2")
    CmbBB.Items.Add("3")
    CmbBB.Items.Add("4")
    CmbBB.Items.Add("5")
```

```
    CmbBB.Items.Add("6")
    CmbBB.Items.Add("7")
    CmbBB.Items.Add("8")
    CmbBB.Items.Add("9")
    CmbBB.Text = 1

'This indicates the number of module builders present for the harvest
    CmbMB.Items.Add("1")
    CmbMB.Items.Add("2")
    CmbMB.Items.Add("3")
    CmbMB.Items.Add("4")
    CmbMB.Items.Add("5")
    CmbMB.Items.Add("6")
    CmbMB.Items.Add("7")
    CmbMB.Items.Add("8")
    CmbMB.Items.Add("9")
    CmbMB.Text = 1

    'Indicates whether automatic or manual triggering will be used

    RadioAutoT.Checked = True
    RadioAutoF.Checked = False

  End Sub

        'Whenver the yes button is selected then save settings
  Private Sub BtnYes_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles
BtnYes.Click
    If CheckAppend.Enabled = True Then
      _append = True
    End If

        'Assign these variables as specified by the operator to be inserted into the header of the
metadata file
    _BBNum = CmbBB.Text
    _MBNum = CmbMB.Text
    _RowSpace = CmbRow.Text
    _HeaderWidth = CmbHeader.Text

    If RadioAutoT.Checked = True Then
      _AutoTrigger = True
    End If

    If RadioAutoF.Checked = True Then
      _AutoTrigger = False
    End If

    _AlwaysRec = ChkRec.Checked

    Me.Close()
    frmMain.Show()
```

```
    End Sub

            'If cancel button is selected then do not save settings and go to main form
    Private Sub BtnCancel_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles
BtnCancel.Click
        Me.Close()
        frmMain.Show()
    End Sub

    'Subroutine for appending data to older file (return harvest)

    Private Sub CheckAppend_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles
CheckAppend.Click
        If lblAppend.Enabled = False Then
            lblAppend.Enabled = True
            CmbFile.Enabled = True
            Try
                'Dim _existfiles() As String = IO.Directory.GetFiles("\Storage Card\Data", "data_*")
                Dim _existfiles() As String = IO.Directory.GetFiles(_wd & "\Data", "data_*")
                Dim _indfile As String
                For Each _indfile In _existfiles
                    Dim _filestr() As String
                    _filestr = Split(_indfile, "\")
                    'CmbFile.Items.Add(_indfile)
                    CmbFile.Items.Add(_filestr(3))
                Next
            Catch ex As Exception
            End Try
        ElseIf lblAppend.Enabled = True Then
            lblAppend.Enabled = False
            CmbFile.Enabled = False
        End If
    End Sub

End Class
```

COLLECT FORM

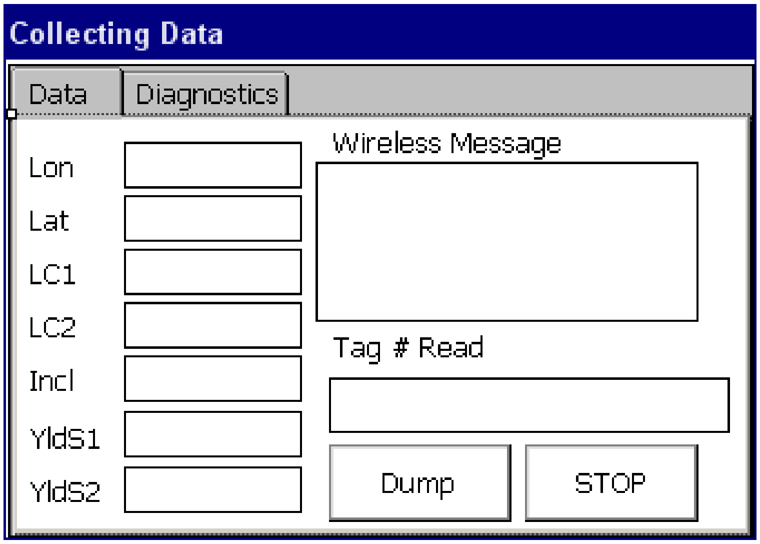


Figure B-3. Collect from display

```
Public Class frmCollect

    'Variables used for yield monitor correction
    Dim _YS1_count, _YS2_count As Integer
    Dim _YS1_min, _YS2_min As Double
    Dim _YS1_sum, _YS2_sum As Double
    Dim _YS1_avg, _YS2_avg As Double
    Dim _YS1_baseline(10), _YS2_baseline(10) As Double
    Dim _baseline_count As Integer
    Dim _count_eff As Integer 'Effective number of IO readings for Yield Sensor 1 and Yield Sensor 2

    'GPS Variables
    Dim _Lat As Double
    Dim _Lon As Double
    Dim _Speed As Double
    Dim _PDOP As Double
    Dim _rawGPS, _prev_rawGPS As String 'string store the raw and previous raw GPS
    Dim _timer_tick As Integer

    'Load cell variables
    Dim _LC_old, _LC_new As Double
    Dim _LC_base As Double = 100.0

    'Basket dump timers and counters
    Dim _timelapse1 As Int32
    Dim _timelapse2 As Int32
    Dim _MSGcounter As Integer
    Dim _TransMSG As String = ""
    Dim _systemcount As Int32
```

```
    Dim _dump As String = ""

    'Sensor Variables
    Dim _Incl As Double
    Dim _LoadCell1, _LoadCell2, _LoadCell As Double
    Dim _DumpTriggerred As Boolean = False

    Private Sub btnSTOP_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles
btnSTOP.Click
        Dim _result As Integer = MsgBox("Stop data collection?", MsgBoxStyle.YesNo)
        If (_result = 6) Then
            'Stop current harvest and exit to frmMain
            'need to close all the hardware collection and data files before exit
            'close serialports 1, 2, and 3
            If SerialPort1.IsOpen() Then
                SerialPort1.Close()
            End If

            If SerialPort2.IsOpen() Then
                SerialPort2.Close()
            End If

            If SerialPort3.IsOpen() Then
                SerialPort3.Close()
            End If
            'close the analogue inputs port
            'CloseHandle(_RLCHandleAnalog)

            'close the data file stream
            _metadata.WriteLine("Harvest End Time: " & CStr(Now()))
            _rawdata.Close()
            _metadata.Close()

            'Me.Hide()
            Me.Close()
            frmMain.Show()
        End If

    End Sub

    Private Sub frmCollect_Load(ByVal sender As Object, ByVal e As System.EventArgs) Handles
MyBase.Load

        '-------------------------------------------------------
        'This piece of codes, together with others, satisfies Dr. Sui's requirement for Yield sensor
baseline correction
        'Initialize variables for yield monitor baseline correction
        _YS1_count = 0
        _YS2_count = 0
        _YS1_sum = 0.0
        _YS2_sum = 0.0
        _YS1_avg = 0.0
```

```
        _YS2_avg = 0.0
        _YS1_min = 100000.0
        _YS2_min = 100000.0
        _count_eff = 0
        _baseline_count = 0

        Dim _i As Integer
        For _i = 0 To 9
            _YS1_baseline(0) = 0.0
            _YS2_baseline(1) = 0.0
        Next

        'Initiates all variables
        _Lat = 0.0
        _Lon = 0.0
        _Speed = 0.0
        _PDOP = 0.0
        _timer_tick = 0
        _rawGPS = ""
        _prev_rawGPS = ""
        _LoadCell1 = 0.0
        _LoadCell2 = 0.0
        _Incl = 0.0

        _timelapse1 = _timelapse2 = 0
        _systemcount = 0
    End Sub


    Private Sub Timer1_Tick(ByVal sender As Object, ByVal e As System.EventArgs) Handles
Timer1.Tick
        'Tasks implemented in Collect() include:
        'GPS reading and extraction
        'Analog reading (YieldSensor1, YieldSensor2, LoadCell1, LoadCell2, Inclinometer)
        Collect()

        'Check Wireless Transceiver
        Dim _WirelessMSG As String = ""
        Dim _ParseMSG() As String
        Try
            _WirelessMSG = SerialPort3.ReadLine()
        Catch ex As Exception
        End Try

        'Modified program to accomodate the new RFID transmission protocol
        'The typical message transmitted from any of the module builder has the form of
        '------"MSG,M1,00,H1003,H2105,76541"------------------

        'If statement divides up the wireless message if there is one and looks to see if
        'message is from module builder (00). Writes the entire message to metadata for storage
        'if correct message. Displays wireless message on screen.
        If _WirelessMSG <> "" Then
```

```
            _ParseMSG = Split(_WirelessMSG, ",")
            If ((_ParseMSG(0) = "MSG") And (_ParseMSG(2) = "00")) Then
                _metadata.WriteLine(_WirelessMSG)
                If _MSGcounter >= 4 Then
                    _MSGcounter = 0
                    txtMSG.Text = ""
                End If
                txtMSG.Text = txtMSG.Text + _WirelessMSG + vbCrLf
                _MSGcounter += 1
            End If
        End If

        '-----automated dump trigger using the reading of inclinometer & load cells
        If _AutoTrigger = True Then
            'If inclinometer falls below 1.2 V (dumping)
            If (Math.Abs(_Incl - 2.405) > _Angle_Threshold) And (_DumpTriggerred = False) Then
                _timelapse1 += 1
                'The basket lifted position has to be maintained for 10s to call ProcessDumpTrigger()
                If (_timelapse1 >= 10) Then
                    Call processDumpTrigger()
                    _DumpTriggerred = True
                    _timelapse2 = 0
                End If
                'Enough time has elapsed so a dump can now take place
            ElseIf (Math.Abs(_Incl - 2.405) < _Angle_Threshold) And (_DumpTriggerred = False) Then
                _timelapse1 = 0
            ElseIf (Math.Abs(_Incl - 2.405) < _Angle_Threshold) And (_DumpTriggerred = True) Then

                'Check for the new load cell value for 15 seconds after the basket is lowered back to seated

                _timelapse2 += 1

                If _timelapse2 = 15 Then

                    'After determining the new LC value, compare.
                    'Load cell percentages need to be included here prior to incrementing the basket number
                    'When 15% or less of the cotton is removed -> NO DUMP
                    'NO DUMP = Don't increment basket number and don't send message(nothing significant
happened)
                    If ((1 - (_LC_new / _LC_old)) <= 0.15) Then
                        _BsktNum = _BsktNum
                        diagBSKT.Text = "NO DUMP, " & ValueToString(_BsktNum)
                        _DumpTriggerred = False
                        _dump = "NO DUMP"
                        'Timer1.Enabled = True

                        'Reinitialize the load cell variables
                        _LC_base = 100.0
                        _LC_old = _LC_new
                        _LC_new = 0.0

                        'FULL DUMP = There is not a significant amount of cotton remaining
```

```
                        'in the basket, increment basket and send message
                    ElseIf ((1 - (_LC_new / _LC_old)) >= 0.85) Then
                        txtMSGT.Text = _TransMSG
                        Try
                            SerialPort3.WriteLine(_TransMSG & vbCrLf)
                        Catch ex As Exception
                            MessageBox.Show(ex.Message)
                            MsgBox("can't send wireless signal", MsgBoxStyle.OkOnly)
                        End Try
                        _BsktNum = _BsktNum + 1
                        diagBSKT.Text = "FULL DUMP, " & ValueToString(_BsktNum)
                        _DumpTriggerred = False
                        _dump = "FULL DUMP"
                        'Timer1.Enabled = True

                        'Reinitialize the load cell variables
                        _LC_base = 100.0
                        _LC_old = _LC_new
                        _LC_new = 0.0

                        'When between 15% and 85% of the cotton is removed -> PARTIAL DUMP
                        'PARTIAL DUMP = A significant amount of cotton was removed don't increment basket
                        'but do send message. (PARTIAL DUMP baskets will possibly be assigned to mulitple
modules)
                    Else
                        txtMSGT.Text = _TransMSG
                        Try
                            SerialPort3.WriteLine(_TransMSG & vbCrLf)
                        Catch ex As Exception
                            MessageBox.Show(ex.Message)
                            MsgBox("can't send wireless signal", MsgBoxStyle.OkOnly)
                        End Try
                        _BsktNum = _BsktNum
                        diagBSKT.Text = "PARTIAL DUMP, " & ValueToString(_BsktNum)
                        _DumpTriggerred = False
                        _dump = "PARTIAL DUMP"
                        'Timer1.Enabled = True

                        'Reinitialize the load cell variables
                        _LC_base = 100.0
                        _LC_old = _LC_new
                        _LC_new = 0.0

                    End If

                    '===========Load cell instruction end================
                End If


            End If
        End If
```

```
    'Make sure the data have been recorded every 15 seconds
    _systemcount += 1
    If (_systemcount Mod 15 = 0) Then
        _rawdata.Close()
        _metadata.Close()
        _rawdata = IO.File.AppendText(_datafilename)
        _metadata = IO.File.AppendText(_metadatafilename)
    End If

    'Autodump diagnostics
    diagTL1.Text = _timelapse1
    diagTL2.Text = _timelapse2
    diagDT.Text = _DumpTriggerred

End Sub
Private Sub processDumpTrigger()
    'Timer1.Enabled = False

    Dim _BsktID As String = ValueToString(_BsktNum)
    Dim _DestID As String = ""
    Dim _Tag(5) As Int32
    '----------------------------------------------------------------------------
    Dim _RFIDquery(4) As Char
    'Dim _RFIDini(4) As Char
    Dim _readcount As Integer

    ' Note the length of this array is proportional to the number of Tags used in the system
    Dim _RFIDres As String = ""
    Dim _j As Integer = 0
    Dim _i, _k As Integer
    Dim _Pos0 As Integer = 0
    Dim _Pos1 As Integer = 0
    Dim _Pos2 As Integer = 0

    Dim _counter1, _counter2 As Integer

    txtTagRead.Text = ""

    '_RFIDini is used to determine what RFID reader the unit is connected to
    '(not required for usual use)
    '_RFIDini(0) = ChrW(&H53)
    '_RFIDini(1) = ChrW(&H42)
    '_RFIDini(2) = ChrW(&H0)
    '_RFIDini(3) = ChrW(&H4)

    '_RFIDquery is the code telling the reader to scan the area
    _RFIDquery(0) = ChrW(&H53)
    _RFIDquery(1) = ChrW(&H42)
    _RFIDquery(2) = ChrW(&H1)
    _RFIDquery(3) = ChrW(&H4)
```

```
'RFID tag needs to be determined prior to whether dump took place since vehicle could
'potentially leave before dump is determined.

'Given the apparent difficulties we run into for the RFID query
'We use a majority vote to decide the Tag number being queried
For _readcount = 1 To 5
  Try
    SerialPort2.Write(_RFIDquery, 0, 4) 'write _RFIDquery line to serial port 2
  Catch ex As Exception
    MsgBox("fail to write RFID cycle:" + CStr(_readcount), MsgBoxStyle.OkOnly)
  End Try

  For _counter1 = 1 To &H7FF
    For _counter2 = 1 To &H3FF
      'Waster some CPU time to wait for the response from RFID
      'helps so that the RFID reader has time to clear memory (no false reads)
    Next
  Next

  Try
    _RFIDres = SerialPort2.ReadExisting()
  Catch ex As Exception
    'debug only
    MsgBox("fail to read RFID cycle:" + CStr(_readcount), MsgBoxStyle.OkOnly)
  End Try


  Dim _RFIDseg() As String = Split(_RFIDres, "T")
  If (UBound(_RFIDseg) >= 1) Then
    'The RFID response package is in the form of:
    '------- 0x53 0x42 < T XXXXXXXXXX T XXXXXXXXXX T XXXXXXXXXX >------
    'In the following need to parse out the RFID Tag information
    'and convert it into the corresponding vehicleID
    'Look up on AJ's RFID instruction
    'txtOther.Text = UBound(_RFIDseg)
    'For _j = 1 To UBound(_RFIDseg)
    Dim _hbyte As Byte = Convert.ToByte(_RFIDseg(1)(2))
    Dim _mbyte As Byte = Convert.ToByte(_RFIDseg(1)(3))
    Dim _lbyte As Byte = Convert.ToByte(_RFIDseg(1)(4))
    _Tag(_j) = _hbyte * &H10000 + _mbyte * &H100 + _lbyte
    _j += 1
  End If
  'txtTag.Text += Hex(_Tag) + vbCrLf
Next

'When j = 0 no RFID tags have been detected by the reader
If _j = 0 Then
  _DestID = "XX"
  _txtTagRead.Text = "Read None"
  'do the majority vote
ElseIf _j > 0 Then
  For _i = 0 To UBound(_Tag) - 1
```

```
                For _k = 0 To 2
                    If (_Tag(_i) = _TagID(_k)) Then
                        If (_k = 0) Then
                            _Pos0 += 1
                        ElseIf (_k = 1) Then
                            _Pos1 += 1
                        ElseIf (_k = 2) Then
                            _Pos2 += 1
                        End If
                    End If
                Next
            Next

            'Assign the majority vote tag to destination/receiving vehicle and display message for
diagnostics
            _DestID = _VhclID(0)
            _txtTagRead.Text = Hex(_TagID(0))

            If ((_Pos1 > _Pos0) Or (_Pos2 > _Pos0)) Then
                If (_Pos1 > _Pos2) Then
                    _DestID = _VhclID(1)
                    _txtTagRead.Text = Hex(_TagID(1))
                ElseIf (_Pos1 < _Pos2) Then
                    _DestID = _VhclID(2)
                    _txtTagRead.Text = Hex(_TagID(2))
                End If
            End If
        End If
        '--------------------------------------------------------------------------
        'Form of the transmitted MSG:
        '[MSG,H1,M1,H1003]
        _TransMSG = "MSG," & _HarvesterID & "," & _DestID & "," & _HarvesterID & _BsktID

        'If manual triggering is enabled this sends messages and increments basket number
        If _AutoTrigger = False Then
            txtMSGT.Text = _TransMSG
            Try
                SerialPort3.WriteLine(_TransMSG & vbCrLf)
            Catch ex As Exception
                MessageBox.Show(ex.Message)
                MsgBox("can't send wireless signal", MsgBoxStyle.OkOnly)
            End Try
            _BsktNum = _BsktNum + 1
            diagBSKT.Text = "FULL DUMP, " & ValueToString(_BsktNum)
            _DumpTriggerred = False
            'Timer1.Enabled = True

            'Reinitialize the load cell variables
            _LC_base = 100.0
            _LC_old = 0.0
            _LC_new = 0.0
```

```
        End If

    End Sub

    Private Sub ExtractGPS()
        Dim _i As Integer
        Dim _Sentence() As String
        Dim _Segment() As String
        Dim _GPSstr As String

        _GPSstr = _prev_rawGPS & _rawGPS
        _Sentence = Split(_GPSstr, "$")

        If (UBound(_Sentence) > 0) Then
            For _i = 0 To UBound(_Sentence)
                If (Len(_Sentence(_i)) > 10) Then
                    _Segment = Split(_Sentence(_i), ",") 'Segment refers to segments in each sentence
                    If _Segment(0) = "GPRMC" Then
                        If UBound(_Segment) > 8 Then
                            _Lat = CDbl(_Segment(3)) 'Extract Latitude
                            If (_Segment(4) = "S") Then
                                _Lat = -1 * _Lat
                            End If
                            _Lon = CDbl(_Segment(5)) 'Extract Longitude
                            If (_Segment(6) = "W") Then
                                _Lon = -1 * _Lon
                            End If
                            _Speed = CDbl(_Segment(7)) 'Extract Speed
                            _Lat = _Lat / 100 'These two lines are questionable, look at the NMEA documents
                            _Lon = _Lon / 100
                        End If
                    End If

                    If _Segment(0) = "GPGSA" Then
                        If UBound(_Segment) > 16 Then
                            _PDOP = CDbl(_Segment(15))
                        End If
                    End If
                End If
            Next
        End If

    End Sub

    Public Sub Collect()

        Dim _j As Integer 'Define variables for the loop;
        'Dim time_difference As Integer ' time_difference is the time difference between the previuos
cycle and the current cycle
        Dim Swath As Double 'swath is the swath width in meter, calculated as headerwidth times [e.g.,
6(row) * 40 (in) * 0.0254(m/in) = 6.096(m)]
        Swath = 6.096
```

```
' Most importantly, read the yield sensors' value from IAIO ports 01 and 02
' Read the values of the sensor, each call read 100 times and also extract the minimum values
_2ndBoard = True
Read_Analog_100()

For _j = 0 To 8   'shift the values in the array
   _YS1_baseline(9 - _j) = _YS1_baseline(9 - _j - 1)
   _YS2_baseline(9 - _j) = _YS2_baseline(9 - _j - 1)
Next _j

'Keep the minimum output on the top of the array;
_YS1_baseline(0) = _YS1_min
_YS2_baseline(0) = _YS2_min

'At this point, _YS1_avg and _YS2_avg are the sums of the minimum
'output values from the sensors;
For _j = 0 To 9
   _YS1_avg = _YS1_avg + _YS1_baseline(_j)
   _YS2_avg = _YS2_avg + _YS2_baseline(_j)
Next _j

' At the first 10 seconds, the number of minimum output values are
' less than 10. So to obtain the average baseline value by dividing
' the sum of baseline by the baseline_count.
' At this point, the _YSx_avg is the average of baseline values;
If (_baseline_count <= 9) Then
   _baseline_count = _baseline_count + 1
   _YS1_avg = _YS1_avg / _baseline_count
   _YS2_avg = _YS2_avg / _baseline_count
   'There are 10 minimum outputs available;
   'At this point, the _YSx_avg is the average of 10 minimum baseline values;
Else
   _YS1_avg = _YS1_avg / 10.0#
   _YS2_avg = _YS2_avg / 10.0#
End If
'-----------------------------------------------------------------------
' display the YieldSensor1 and YieldSensor2 (NOT baseline corrected?) values on the form
txtYS1.Text = CInt(_YS1_sum * 1000 / _count_eff) / 1000
txtYS2.Text = CInt(_YS2_sum * 1000 / _count_eff) / 1000
' Calculate the output signal values with substracting the baseline
' This is the actual number that should be involved in post processing and calculation
_YS1_sum = (_YS1_sum / _count_eff) - _YS1_avg
_YS2_sum = (_YS2_sum / _count_eff) - _YS2_avg


' Step 2: read the data from the GPS port, which is COM1 on the SBC main board
'------------------------------------------------------------
'Note: should this be: [rawdata = GPSport.readexisting()]
'------------------------------------------------------------
Try
   _rawGPS = SerialPort1.ReadExisting()
```

```
Catch ex As Exception
End Try
'Check if there is an communication event occured at the GPSport;
'if no data in rawdata then no communication
If (_rawGPS = "") Then
   ' initialize the variables
   'prev_time = 0
   'current_time = 0
   _Lat = 0.0
   _Lon = 0.0
   _Speed = 0.0
   _PDOP = 0.0
   ' increment the timer_tick
   _timer_tick = _timer_tick + 1

   ' If _timer_tick is counted up to 5, GPS error is assumed,
   ' then GPS error message should be displayed on the form;
   If (_timer_tick > 5) Then
      ' play beep sound to convey GPS error
      'PlayWaveFile("\Storage Card\RINGOUT.wav")
      ' display the GPS error message in Form2
      If (lblLon.Visible = True) Then
         lblLon.Visible = False
      Else
         lblLon.Visible = True
      End If
   End If

Else
   ' There is data at the GPSport;
   _timer_tick = 0 'set the _timer_tick back to 0,
   txtLon.Visible = True  'remove the GPS error warning on the form
   ' Extract the lat, lon and speed from the GPS signal (rawdata)
   ' by using subroutine "ExtractPosition".
   ExtractGPS()
End If
txtLat.Text = _Lat ' Display the latitude
txtLon.Text = _Lon ' Display the longitude

' Step 3: Read Load Cell inputs (Analog 0 & 1) and inclinometer input (Analog 2) from the GPIO board
'-----------------------------------------------------------------
_2ndBoard = False
Read_Analog_15()

'Find the minimum load cell value
If _LoadCell < _LC_base Then
   _LC_base = _LoadCell
End If

'Find the new maximum load cell value
If _DumpTriggerred = True Then
```

```
                'Subtract the base reading of the load cell to get a more accurate value
            If (_LoadCell - _LC_base) > _LC_new Then
                _LC_new = (_LoadCell - _LC_base)
            End If

        End If

        'Find the old maximum load cell value, again subtract the base value prior to comparing
        If (_LoadCell - _LC_base) > _LC_old Then
            _LC_old = (_LoadCell - _LC_base)
        End If

'Display sensor readings on the collect form
        _txtLC1.Text = _LoadCell1
        _txtLC2.Text = _LoadCell2
        _txtIncl.Text = _Incl
        '-------------------------------------------------------------

        'write data to file
        'If the GPS signal is received and if the ground speed is greater than 1 knots (1 knot = 0.514
m/s)
        '( no GPS signal and too small ground speed will result in no data recording)
        If _AlwaysRec Then
            Try
                _rawdata.WriteLine(CStr(_Lon) & "," & CStr(_Lat) & "," & CStr(Math.Round(1.15078030303
* _Speed, 3)) & _
                                ","  & _PDOP & "," & CStr(Math.Round(_YS1_sum, 3)) & "," &
CStr(Math.Round(_YS2_sum, 3)) & _
                                "," & CStr(Math.Round(_LoadCell1, 3)) & "," & CStr(Math.Round(_LoadCell2, 3)) &
"," & _
                                CStr(Math.Round(_Incl, 3)) & "," & ValueToString(_BsktNum) & "," &
_DumpTriggerred & "," & _dump)
            Catch ex As Exception
            End Try

        ElseIf Not _AlwaysRec Then
            If ((_Speed > 1.0) And (_rawGPS <> "")) Then
                Try
                    _rawdata.WriteLine(CStr(_Lon) & "," & CStr(_Lat) & "," &
CStr(Math.Round(1.15078030303 * _Speed, 3)) & _
                                        "," & _PDOP & "," & CStr(Math.Round(_YS1_sum, 3)) & "," &
CStr(Math.Round(_YS2_sum, 3)) & _
                                        "," & CStr(Math.Round(_LoadCell1, 3)) & "," & CStr(Math.Round(_LoadCell2, 3))
& "," & _
                                        CStr(Math.Round(_Incl, 3)) & "," & ValueToString(_BsktNum))
                Catch ex As Exception
                End Try
            End If
        End If

        're-initialize values for the next cycle of data collection
```

```
    _YS1_sum = 0.0#
    _YS1_avg = 0.0#
    _YS2_sum = 0.0#
    _YS2_avg = 0.0#

    _LoadCell1 = 0.0#
    _LoadCell2 = 0.0#
    '_Incl = 0.0#

    _count_eff = 0
    _YS1_min = 100000.0#
    _YS2_min = 100000.0#
    _prev_rawGPS = _rawGPS
    _rawGPS = ""

  End Sub

  Public Sub Read_Analog_100()

    Dim _i As Integer 'Define variable for loop;
    Dim Voltages(2) As Object ' Voltages(2) is the array into which sensor 1 and sensor 2 values are
read into
    ' loop till 100 values are obtained from the sensor
    For _i = 0 To 99
      ' There is opportunity to read 100 readings with one command, provided by XScale_RLC
example codes
      ' read value for sensor 1 from differential port 1 (range 0 - 5V)
      Voltages(0) = Read_Analog(0, 0)
      ' read value of sensor 2 from differential port 2 (range 0 - 5V)
      Voltages(1) = Read_Analog(1, 0)
      ' multiply with -1: given in the manual to do so
      ' Reversed hardware connection indicated by Dr. Sui
      'Voltages(0) = (-1) * Voltages(0)
      'Voltages(1) = (-1) * Voltages(1)
      ' sum sensor 1 values
      _YS1_sum = _YS1_sum + Voltages(0)
      ' Sort and keep a minimum output value from sensor 1
      If (Voltages(0) < _YS1_min) Then
        _YS1_min = Voltages(0)
      End If
      ' sum sensor 2 values
      _YS2_sum = _YS2_sum + Voltages(1)
      ' sort and keep a minimum output value from sensor 2
      If (Voltages(1) < _YS2_min) Then
        _YS2_min = Voltages(1)
      End If
      ' Effective number of readings
      _count_eff = _count_eff + 1
    Next _i

  End Sub
```

```
Public Sub Read_Analog_15()

  Dim _i As Integer
  Dim _Channel0, _Channel1, _Channel2 As Double
  _Channel0 = 0.0
  _Channel1 = 0.0
  _Channel2 = 0.0

  'Take 15 readings from the analog ports each second
  For _i = 1 To 15
    _Channel0 = _Channel0 + Read_Analog(0, 0)
    _Channel1 = _Channel1 + Read_Analog(1, 0)
    _Channel2 = _Channel2 + Read_Analog(2, 0)
  Next

  'Find the average of the of the 15 readings (decreases noise)
  _LoadCell1 = CInt(_Channel0 * 1000 / 15) / 1000
  _LoadCell2 = CInt(_Channel1 * 1000 / 15) / 1000
  _Incl = CInt(_Channel2 * 1000 / 15) / 1000
  _LoadCell = _LoadCell1 + _LoadCell2

End Sub
'Function to read from a specific channel at a certain range.
'This function is from RLC
Public Function Read_Analog(ByVal channel As Integer, ByVal range As Integer) As Double
  Dim Raw As Integer
  ' Function to get Analog input
  '  -declared in GPIOdecals
  Raw = GPIO_Analog_In(channel, range)
  ' do Specified Conversions
  Select Case range
    Case 0
      ' Range is 0-5 Volts
      Read_Analog = (((Raw * 5) / 4096))
    Case 1
      ' Range is +/- 5 Volts
      If (Raw And &H800) = &H800 Then
        Raw = Raw Or &HF000
      End If
      Read_Analog = ((Raw * 10) / 4096)
    Case 2
      ' Range is 0-10 Volts
      Read_Analog = (((Raw * 10) / 4096))
    Case 3
      ' Range is +/- 10 Volts
      If (Raw And &H800) = &H800 Then
        Raw = Raw Or &HF000
      End If
      Read_Analog = ((Raw * 20) / 4096)
  End Select
End Function
```

```
    'This subroutine is for when manual triggering is enabled

    Private Sub btnDump_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles
btnDump.Click
        If _AutoTrigger = False Then
            processDumpTrigger()
        End If
    End Sub
End Class
```

MODULE 1

```
Module Module1

   Public _rawdata As IO.StreamWriter 'stream write for the raw datafile, the file is stored "\SDCard\data_i.txt"
   Public _metadata As IO.StreamWriter 'stream write for the meta file, the file is stored "\SDCard\metadata_i.txt"
   Public _datafilename As String 'the data file name for current data collection
   Public _metadatafilename As String 'the metadata file name for current data collection

   Public _append As Boolean = False 'indicate if append a data file or start a new file
   Public _BBNum As Integer = 1
   Public _MBNum As Integer = 1 'Number of BB (default 1) and MB (default 1) used in harvest
   Public _RowSpace As Integer = 40
   Public _HeaderWidth As Integer = 6 ' the row space [default to 40 (in.)] and the header width (default to 6 rows)
   Public _AutoTrigger As Boolean = True ' indicate if autotrigger by inclinometer should be used
   Public _AlwaysRec As Boolean = False ' indicate if Record should always happen (for debugging purpose)
   Public _2ndBoard As Boolean = False
   Public _wd As String = "\SDCard\Data" ' the working directory

   'Variables required for RLC computer operation and use of inputs

   Const AIN_A_LSB = &H60
   Const AIN_A_MSB = &H64
   Const AOUT_LSB_BASE = &H80
   Const AOUT_MSB_BASE = &H90
   Const AOUT_LOAD = &HA0
   Const IOUT_A_LATCH = &HA4
   Const IOUT_B_LATCH = &HA8

   Const AIN_A_LSB2 = &H160
   Const AIN_A_MSB2 = &H164
   Const AOUT_LSB_BASE2 = &H180
   Const AOUT_MSB_BASE2 = &H190
   Const AOUT_LOAD2 = &H1A0
   Const IOUT_A_LATCH2 = &H1A4
   Const IOUT_B_LATCH2 = &H1A8

   Public Declare Sub RLC_WriteUSER_IO Lib "rlc_arm.dll" (ByVal offset As Integer, ByVal val As Integer)
   Public Declare Function RLC_ReadUSER_IO Lib "rlc_arm.dll" (ByVal offset As Integer) As Integer
   Public Declare Sub RLC_InitUSER_INT Lib "rlc_arm.dll" (ByVal UserIntNum As Integer, ByRef IntEvent As Integer)
   Public Declare Function RLC_PollUSER_INT Lib "rlc_arm.dll" (ByVal UserIntNum As Integer) As Integer

   '*******************************************************************************
   ' GPIO_Analog_In - Read from Analog input channel
```

```
'  channel = 0 - 5
'  range   = 0 - Range = 0 to +5Vdc.
'  range   = 1 - Range = -5 to +5Vdc.
'  range   = 2 - Range = 0 to +10Vdc.
'  range   = 3 - Range = -10 to +10Vdc.
'*******************************************************************************
Function GPIO_Analog_In(ByVal channel As Integer, ByVal range As Integer) As Integer
  Dim Analog_Val As Integer
  Dim Read_Cmd As Integer
  Dim temp As Integer
  Dim counter As Integer

  'Since ours is a 2nd board (i.e., stacked IO boards, JP5 set to 2-3
  'If Not Form1.CheckBox1.Checked Then 'CS1
  If _2ndBoard = False Then 'Read 2nd Board
    Read_Cmd = &H40 Or ((range And &H3) * 8)
    Read_Cmd = Read_Cmd Or (channel And &H7)
    RLC_WriteUSER_IO(AIN_A_LSB, Read_Cmd)
  Else 'Read 1st Board
    Read_Cmd = &H40 Or ((range And &H3) * 8)
    Read_Cmd = Read_Cmd Or (channel And &H7)
    RLC_WriteUSER_IO(AIN_A_LSB2, Read_Cmd)
  End If

  counter = 0
  Do
    temp = RLC_PollUSER_INT(3)
    counter += 1
  Loop While (temp = 1 And counter <= 100000)

  If _2ndBoard = False Then
    Analog_Val = RLC_ReadUSER_IO(AIN_A_LSB)
    Analog_Val = Analog_Val Or ((RLC_ReadUSER_IO(AIN_A_MSB) And &HF) * 256)
    GPIO_Analog_In = Analog_Val
  Else
    Analog_Val = RLC_ReadUSER_IO(AIN_A_LSB2)
    Analog_Val = Analog_Val Or ((RLC_ReadUSER_IO(AIN_A_MSB2) And &HF) * 256)
    GPIO_Analog_In = Analog_Val
  End If

End Function

Public Function ValueToString(ByVal _Number As Integer) As String

  If _Number > 999 Or _Number < 0 Then
    Return "000"
  End If

  If _Number > 99 Then
    Return Str(_Number)
  ElseIf _Number > 9 Then
    Return "0" & Right(Str(_Number), 2)
```

```
        Else
            Return "00" & Right(Str(_Number), 1)
        End If

    End Function

    'here define the query commands for RFID reader
    '---------------This list needs to be expanded if there are more vehicles during harvest
    '---------------Currently we use three vehicles (one boll buggy and two module builder for
demonstration
    Public _VhclID() As String = {"B1", "M1", "M2"}  'This is the list of the physical IDs of vehicles in
harvest
    'Public _TagID() As Int32 = {70173, 70106, 70558}  'This is the RFID TAG numbers attached to
corresponding vehicles
    Public _TagID() As Int32 = {&H70173, &H70106, &H70558}
    Public Const _HarvesterID = "H1"

    Public Const _Angle_Threshold = 1.2
    Public _BsktNum As Integer

End Module
```

APPENDIX C

MODULE AVERAGED AND BALE FIBER QUALITY DATA

Module Averages – IMPACT Center

Module	# of Bales	Module Net (lb)	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
7731	13	6206	51	34	3	3.9	69.8	8	107	25.8	78.4
7732	13	6234	46	35	3	3.8	71.5	8	108	25.8	78.3
7733	19	8956	42	35	3	3.7	72.1	8	109	26.1	78.6
7734	17	7985	49	35	4	3.9	70.1	8	109	26.7	78.9
7735	15	7402	44	35	3	4.1	71.9	25	101	25.2	58.9
7736	19	9250	49	34	3	4.1	70.5	18	103	25.6	66.8

Module Averages – Lubbock

Module	# of Bales	Module Net (lb)	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
10001	11	18000	31	38	4	39	80.0	068	120	30.9	81.7
10002	11	16000	23	36	3	36	80.9	077	110	28.5	80.3
10003	11	16020	31	37	4	37	80.6	070	116	30.1	81.4
10004	11	17020	31	38	4	42	80.7	067	118	29.9	81.4
10005	11	16640	31	38	4	39	80.5	067	118	30.2	80.8
10006	11	16780	22	36	3	38	80.5	081	111	28.2	81.2
10007	11	19620	31	37	3	37	73.7	071	117	30.2	80.3
10008	12	15420	20	34	3	34	80.7	083	107	27.9	80.7
10009	10	16640	25	35	3	35	81.1	076	111	29.1	80.9

Individual Bales – IMPACT Center

Module	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
7731	51	34	3	3.8	69.6	8.1	105	26.4	78.7
	51	34	4	3.9	69.3	7.6	105	26.1	77.2
	51	34	3	3.8	67.8	7.7	107	25.3	77.2
	51	35	3	4	68.7	7.8	108	26.8	78.2
	51	35	3	3.8	69.3	7.7	108	26.5	78.7
	51	35	3	3.9	69.4	7.8	109	25.8	79.7
	51	35	3	3.8	70.2	7.5	108	25	78.9
	51	34	3	3.9	71	7.8	106	24.3	77.3
	51	35	3	3.9	70.5	7.6	109	26.9	79.5
	51	34	3	3.8	70.4	7.4	107	25.3	77.6
	51	35	3	3.9	70.3	7.7	108	25.5	79.2
	51	34	3	3.7	70.8	7.5	107	25.2	78.9
	51	34	3	3.9	70.5	7.7	107	26	78.5
7732	51	35	3	3.8	71.5	7.4	108	26	76.4
	51	34	3	3.7	71.1	7.5	105	24.9	78.3
	41	35	4	3.7	71.5	7.9	108	26.5	79.5
	51	35	4	3.8	71.4	7.8	110	25.6	79.2
	51	36	4	3.9	71.3	7.8	112	26.6	79.3
	41	35	3	3.8	71.6	7.6	108	26.9	78.8
	41	34	3	3.8	71.8	7.7	106	24.7	78.1
	41	34	3	3.7	71.9	7.9	106	24.8	76.1
	41	35	3	3.8	71.6	7.7	109	26.3	78.8
	41	34	3	3.7	71.8	7.8	107	25	78.3
	51	35	3	3.8	71.1	7.4	110	26.7	78.5
	51	34	3	3.7	71.3	7.4	107	25.6	78.1
	51	34	3	3.7	71.4	7.4	107	25.9	78.2
7733	41	34	3	3.6	72.3	7.8	106	24.9	77.4
	51	35	3	3.7	71.8	7.5	108	26.6	78.3
	41	35	4	3.7	72.1	7.7	108	24.9	79.2
	41	34	3	3.6	72	7.6	107	26.7	78
	41	35	4	3.7	72.3	7.8	108	25.6	78.2
	41	35	4	3.7	72.5	7.9	109	25.6	77.8
	51	35	3	3.7	71.9	7.5	110	26.3	78.4
	41	35	3	3.6	72.2	7.7	109	26.2	78.8
	41	35	3	3.7	72.7	7.9	110	25.8	79.5
	41	36	4	3.7	72.5	7.7	111	26.8	79

Module	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
	41	35	4	3.7	71.9	7.7	110	24.9	78.4
	41	36	3	3.6	72.1	7.7	112	26.5	79.1
	41	35	4	3.8	71.6	7.6	109	25.9	77.8
	41	35	3	3.7	72.1	7.9	109	27.7	78.1
	41	36	3	3.7	71.8	7.7	111	25.8	79.5
	41	36	3	3.8	72.2	7.8	111	27.4	79.7
	41	35	4	3.7	72.1	7.7	109	26.6	78.1
	41	36	3	3.8	72.3	7.9	112	26.9	80.1
	41	34	3	3.8	71.2	8.2	106	25.4	78.2
7734	52	35	5	4.1	65.3	8.5	109	27.3	80.5
	51	35	4	4	67.5	7.8	109	25.5	79.7
	51	36	3	4	69.3	7.8	111	26.2	79.3
	51	36	4	3.9	70.1	8.1	111	26	79.2
	51	35	3	3.9	70.3	7.9	108	27.3	79.3
	51	34	4	3.9	70.5	7.8	107	26.2	78.4
	41	35	4	3.9	70.6	8	108	25.3	78.6
	51	36	3	3.9	70.1	7.8	111	27.2	80.1
	51	36	4	3.9	71	7.8	111	26.6	78.8
	51	35	3	3.9	71.1	7.7	108	25.7	79
	51	36	4	3.9	71.3	7.9	111	26.7	79.8
	51	35	4	3.8	70.7	7.7	108	27.2	78.8
	51	35	4	3.8	70.5	7.6	110	28.4	78.7
	51	35	4	3.8	69.9	7.7	109	27.3	77.3
	51	35	4	3.8	70.3	7.7	108	26.9	77.6
	41	34	3	3.8	70.6	8	107	27	77.8
	41	35	3	4.1	72.3	7.8	110	26.4	77.8
7735	41	34	3	4.1	72.1	7.9	107	27.5	77.9
	41	35	3	4.1	72.3	7.9	108	27.2	78.6
	41	34	3	4.1	72.2	7.8	105	26.2	78.2
	41	34	3	4.1	71.7	7.8	107	26.6	78.1
	41	35	4	4.2	72.3	7.7	109	26.4	79
	41	35	3	4.1	71.7	7.7	110	26.5	79.9
	51	36	4	4.1	71.6	7.5	111	27	79.3
	41	35	3	4.1	71.6	7.7	109	28.1	79.3
	51	35	4	4.2	71.3	7.8	110	25.9	78.9
	41	35	3	4.1	71.9	7.8	108	27.3	78.8
	51	35	3	4.1	71.4	7.9	110	26	80.2

Module	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
	41	35	3	4.1	71.6	7.9	110	27.2	80.2
	41	35	3	4.2	72.1	8	108	25.9	79.3
	51	35	3	4.1	71.4	7.9	110	27.3	80
	41	35	4	4.1	71.8	7.7	110	27.1	78.1
7736	41	35	3	4.1	71.8	7.9	108	25.7	78.5
	41	35	3	4.1	71.5	7.6	109	27.9	78.7
	51	34	3	4.2	70.6	7.8	107	25.9	78
	51	35	4	4.1	70.8	7.6	109	27.2	78.9
	51	34	3	4.1	71.2	7.8	105	26.3	78.6
	51	34	3	4.1	70.8	7.6	106	26.1	78.3
	51	35	3	4.1	71.2	7.9	108	26.9	79.2
	51	34	3	4.1	70.3	8.1	106	25.9	78.1
	41	33	3	4.1	70.9	8	104	27.3	77.6
	51	35	3	4.1	70.6	7.8	108	25.8	79.1
	51	34	4	4.1	70.1	7.6	107	27.3	78.7
	41	35	3	4.1	70.5	8.1	110	26.4	78.9
	51	34	3	4	69.9	7.9	107	26.1	79.4
	51	34	4	4	69.8	7.9	107	25.7	79
	51	35	3	4.1	70.2	7.9	110	26.9	79.3
	51	34	4	4	69.7	7.7	105	25.8	78.7
	51	34	3	4.1	70.2	8	105	26.7	77.2
	51	34	4	4.2	69.3	7.9	107	27	77.6
	51	35	3	4.2	69	7.8	109	27.4	78.6

Individual Bales – Lubbock

Module	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
10001	31	38	4	34	80.1	6.8	119	32	82
	31	39	4	39	80.2	6.9	122	30.8	82.1
	31	39	4	39	80.1	6.8	122	31	82.4
	31	39	4	39	79.5	6.9	123	31.5	82
	31	38	4	40	79.9	6.8	119	31.7	82
	31	38	4	40	80.2	6.8	120	30.9	81.9
	31	38	5	40	79.5	6.6	119	29.2	81.2
	31	38	5	39	79.9	6.8	119	31.1	82.3
	31	38	5	39	79.8	6.5	120	30.9	80.6
	31	37	5	40	80.1	6.8	115	30.4	80.1

Module	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
	31	38	4	39	80.6	6.6	120	30.3	81.7
10002	31	36	3	40	80.6	7.4	113	29.3	80.6
	21	36	3	33	81	7.8	112	30.2	81.5
	21	35	3	34	81.3	7.7	109	28.2	80.1
	21	35	3	35	80.6	7.8	109	28.5	79.8
	21	35	3	35	80.9	7.9	108	28.6	80.6
	21	35	3	37	80.9	7.6	109	28.1	79
	21	36	3	38	80.5	7.8	113	29.2	81.2
	21	36	3	37	81	7.9	111	28.2	80.5
	21	36	3	37	81.1	8.0	111	27.4	81.1
	21	35	3	37	81.1	7.8	108	26.8	79.5
	31	36	4	36	80.5	7.5	112	29.3	79.1
10003	31	37	5	37	80.2	7.2	114	28.8	81.7
	31	38	4	37	80.8	7.1	119	30.3	82.3
	31	37	4	38	80.6	7.1	117	30.3	81.2
	31	37	4	42	81.1	7.0	116	30.6	82.4
	31	36	4	37	80.6	7.1	113	30.7	79.9
	31	37	4	38	81.4	6.8	116	30.3	81.4
	31	37	3	38	80.5	7.0	114	29.4	80.5
	31	37	4	37	80.6	6.8	117	31.2	82.1
	31	37	4	35	80.1	7.1	114	29.3	81.2
	31	38	4	35	80	7.2	118	31	81.2
	31	37	4	34	80.6	7.0	116	29.3	81.2
10004	31	38	4	42	80.2	6.9	119	31.3	81.5
	31	37	4	43	81.1	6.8	116	30	81.5
	31	38	4	43	80.8	6.7	120	30.5	81.9
	31	38	4	42	80.7	6.7	119	31.2	82.1
	31	38	4	41	80.8	6.5	118	29.6	79.8
	31	38	4	41	80.9	6.6	118	29	80.9
	31	38	3	42	80.8	6.9	120	30.3	81.8
	31	38	4	43	80.7	6.7	119	28.9	81.8
	31	38	4	45	80.9	6.8	119	29.8	81.2
	31	38	4	41	81	6.4	120	29.5	82.6
	31	37	4	43	80.1	6.7	115	29.2	80.4
10005	31	39	4	39	81	6.5	121	29.9	80.9
	31	39	4	39	80.6	6.7	122	32.8	81.8
	31	37	4	39	80.4	6.6	117	30.4	80.8
	31	36	4	39	80.6	6.9	113	28.9	77.6
	31	38	4	38	80.7	6.8	119	30	80.4

Module	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
	31	38	4	38	80.5	6.7	119	30	80.3
	31	38	4	39	80.2	6.7	119	30.1	81.6
	31	38	3	41	79.5	6.9	119	29.9	82.3
	31	38	4	40	80.6	6.7	119	30	82
	31	38	4	40	80.3	6.5	118	29.8	80.7
	31	37	4	41	81	6.7	117	29.9	80.3
10006	31	37	3	39	80.8	7.3	114	29.1	81.5
	21	36	3	38	80.5	8.0	111	28.1	79.9
	21	37	3	40	80.2	8.1	114	27.9	82
	21	35	3	39	80.3	8.1	110	26.9	81
	21	35	3	38	80.7	8.1	108	29	81.3
	21	35	3	39	80.6	8.1	110	28.7	81
	21	35	3	38	79.8	8.4	110	28.2	81.2
	21	36	3	37	79.5	8.4	113	28.6	81.6
	21	37	3	38	81	8.4	114	27.3	80.8
	21	35	3	38	81	8.2	110	27.4	81.5
	21	36	3	39	81.1	8.1	111	28.9	81.9
10007	31	37	3	37	81	7.1	117	30.3	80.1
	31	37	4	36	80.5	7.1	115	29.6	80.8
	31	37	4	35	8.1	7.1	117	31.07	79.9
	31	39	3	36	80.3	7.0	121	30.8	80.5
	31	37	3	35	80.3	7.2	116	31.2	80.5
	31	37	4	34	80	7.4	116	31.2	79.5
	31	37	3	34	80.3	7.3	114	28.5	80.5
	31	37	4	35	80.1	7.2	116	29.8	80.2
	31	37	3	40	79.6	7.2	117	30.3	80.2
	31	37	3	40	80.1	7.0	117	29.6	80.2
	31	38	3	40	80.5	6.8	118	29.9	80.7
10008	21	34	3	34	80.6	8.4	105	29.3	80.3
	21	34	3	43	80.8	8.1	105	24	80.4
	21	34	3	32	81	8.6	107	29.7	80
	21	34	3	35	81	8.2	106	26.3	80.3
	21	35	3	34	80.7	8.2	110	28.6	81.6
	21	35	3	35	80.7	8.1	109	27.7	81.1
	21	34	3	34	80.7	8.0	107	27	80.5
	21	34	3	32	80.1	8.2	107	29.1	79.5
	11	34	3	33	80.6	8.9	107	28	81.1
	21	35	3	32	80.2	8.2	108	27.6	81
	21	35	3	32	80.6	8.2	108	28.4	81.6

Module	CGr	Staple	Leaf	Mic	Rd	+b	Length	Strength	Uniformity
	21	35	3	30	80.9	8.0	109	28.6	80.4
10009	21	35	3	37	80.9	7.8	110	29.8	80.9
	21	36	3	36	81	7.7	113	29.3	81.7
	21	35	3	35	81.1	7.7	110	29	80.8
	31	35	3	34	81.3	7.5	109	28.6	80.4
	21	35	3	36	81.5	7.5	110	30.2	80.5
	21	35	3	35	81	7.6	109	28.1	81.2
	31	36	3	35	81	7.5	112	29.3	81.2
	21	35	3	35	81	7.6	110	28.3	82.1
	31	36	3	35	80.9	7.5	112	29.9	80.8
	31	36	3	34	81.1	7.5	111	28.2	79.8

APPENDIX D

OBJECTIVE 1 – SAMPLE DATA

Lat	long	Speed	Inclinometer	Load1	Load2	Yield1	Yield2	Time	Basket	Module
-10148.5152	3341.0794	2.62	2.369	1.031	0.885	0.032	0.034	12:47:37 PM	4	10007
-10148.5161	3341.0794	2.62	2.403	0.951	0.945	0.032	0.034	12:47:38 PM	4	10007
-10148.517	3341.0795	2.65	2.448	0.923	0.97	0.032	0.034	12:47:39 PM	4	10007
-10148.5179	3341.0794	2.58	2.395	0.945	0.946	0.032	0.034	12:47:40 PM	4	10007
-10148.5188	3341.0794	2.58	2.358	0.898	0.967	0.032	0.034	12:47:41 PM	4	10007
-10148.5197	3341.0794	2.6	2.379	0.982	0.928	0.032	0.034	12:47:42 PM	4	10007
-10148.5205	3341.0794	2.54	2.391	0.964	0.938	0.032	0.034	12:47:43 PM	4	10007
-10148.5214	3341.0794	2.56	2.383	0.911	0.919	0.032	0.034	12:47:44 PM	4	10007
-10148.5223	3341.0794	2.58	2.368	0.948	0.886	0.032	0.034	12:47:45 PM	4	10007
-10148.5231	3341.0794	2.52	2.39	0.957	0.982	0.032	0.034	12:47:46 PM	4	10007
-10148.524	3341.0794	2.52	2.352	1.005	0.944	0.032	0.034	12:47:47 PM	4	10007
-10148.5248	3341.0794	2.55	2.368	1.01	0.888	0.032	0.034	12:47:48 PM	4	10007
-10148.5257	3341.0793	2.53	2.443	0.964	0.956	0.032	0.034	12:47:49 PM	4	10007
-10148.5265	3341.0793	2.54	2.374	0.924	0.974	0.032	0.034	12:47:50 PM	4	10007
-10148.5274	3341.0793	2.58	2.304	0.945	0.964	0.032	0.034	12:47:51 PM	4	10007
-10148.5283	3341.0792	2.57	2.367	0.924	0.932	0.032	0.034	12:47:52 PM	4	10007
-10148.5292	3341.0792	2.58	2.4	0.905	0.979	0.032	0.034	12:47:53 PM	4	10007
-10148.53	3341.0792	2.63	2.375	0.895	1.005	0.032	0.034	12:47:54 PM	4	10007
-10148.5309	3341.0793	2.59	2.299	0.969	0.957	0.032	0.034	12:47:55 PM	4	10007
-10148.5318	3341.0793	2.6	2.355	1.003	0.954	0.032	0.034	12:47:56 PM	4	10007
-10148.5327	3341.0793	2.57	2.381	0.95	0.984	0.032	0.034	12:47:57 PM	4	10007
-10148.5336	3341.0793	2.62	2.357	0.975	0.961	0.032	0.034	12:47:58 PM	4	10007
-10148.5344	3341.0793	2.52	2.367	0.986	0.948	0.032	0.034	12:47:59 PM	4	10007
-10148.5353	3341.0793	2.58	2.398	0.969	0.955	0.032	0.034	12:48:00 PM	4	10007
-10148.5361	3341.0793	2.54	2.319	1.008	0.925	0.032	0.034	12:48:01 PM	4	10007
-10148.537	3341.0792	2.56	2.403	0.966	0.915	0.032	0.034	12:48:02 PM	4	10007

Lat	long	Speed	Inclinometer	Load1	Load2	Yield1	Yield2	Time	Basket	Module
-10148.5379	3341.0792	2.58	2.369	0.962	0.943	0.032	0.034	12:48:03 PM	4	10007
-10148.5387	3341.0791	2.61	2.375	0.96	1	0.032	0.034	12:48:04 PM	4	10007
-10148.5396	3341.0791	2.62	2.365	0.914	0.969	0.032	0.034	12:48:05 PM	4	10007
-10148.5405	3341.0792	2.6	2.403	0.98	0.92	0.032	0.034	12:48:06 PM	4	10007
-10148.5414	3341.0792	2.61	2.338	0.993	0.909	0.032	0.034	12:48:07 PM	4	10007
-10148.5423	3341.0792	2.56	2.426	0.964	1.015	0.032	0.034	12:48:08 PM	4	10007
-10148.5431	3341.0792	2.6	2.368	1.01	0.97	0.032	0.034	12:48:09 PM	4	10007
-10148.544	3341.0792	2.61	2.363	0.871	0.968	0.032	0.034	12:48:10 PM	4	10007
-10148.5449	3341.0792	2.58	2.328	0.996	0.92	0.032	0.034	12:48:11 PM	4	10007
-10148.5458	3341.0792	2.6	2.349	0.972	0.962	0.032	0.034	12:48:12 PM	4	10007
-10148.5466	3341.0792	2.39	2.335	0.891	0.994	0.032	0.034	12:48:13 PM	4	10007
-10148.5474	3341.0791	2.14	2.422	0.966	0.97	0.032	0.034	12:48:14 PM	4	10007
-10148.5481	3341.0791	1.97	2.352	0.978	0.993	0.032	0.034	12:48:15 PM	4	10007
-10148.5487	3341.0791	1.94	2.313	1.006	0.968	0.032	0.034	12:48:16 PM	4	10007
-10148.5494	3341.0791	1.98	2.408	0.943	1.012	0.032	0.034	12:48:17 PM	4	10007
-10148.5501	3341.0791	2.03	2.394	0.946	1.01	0.032	0.034	12:48:18 PM	4	10007
-10148.5507	3341.0791	1.95	2.384	0.931	1.009	0.032	0.034	12:48:19 PM	4	10007
-10148.5514	3341.0791	1.96	2.37	0.981	0.974	0.032	0.034	12:48:20 PM	4	10007
-10148.5521	3341.0791	1.97	2.385	0.988	1.017	0.032	0.034	12:48:21 PM	4	10007
-10148.5527	3341.0792	1.99	2.382	0.991	0.995	0.032	0.034	12:48:22 PM	4	10007
-10148.5534	3341.0792	1.97	2.392	1.013	0.996	0.032	0.034	12:48:23 PM	4	10007
-10148.5541	3341.0791	2.01	2.417	0.917	1.008	0.032	0.034	12:48:24 PM	4	10007
-10148.5547	3341.0791	1.95	2.363	0.971	1.02	0.032	0.034	12:48:25 PM	4	10007
-10148.5554	3341.0791	1.99	2.383	0.989	0.998	0.032	0.034	12:48:26 PM	4	10007
-10148.5561	3341.079	1.95	2.396	0.916	1.008	0.032	0.034	12:48:27 PM	4	10007
-10148.5567	3341.079	1.99	2.393	1.031	1.01	0.032	0.034	12:48:28 PM	4	10007

Lat	long	Speed	Inclinometer	Load1	Load2	Yield1	Yield2	Time	Basket	Module
-10148.5574	3341.079	1.97	2.37	0.972	1.012	0.032	0.034	12:48:29 PM	4	10007
-10148.5581	3341.079	1.98	2.375	0.985	1.018	0.032	0.034	12:48:30 PM	4	10007
-10148.5587	3341.079	1.98	2.369	1.006	0.976	0.032	0.034	12:48:31 PM	4	10007
-10148.5594	3341.079	1.97	2.382	1.004	0.976	0.032	0.034	12:48:32 PM	4	10007
-10148.56	3341.0791	1.93	2.369	0.989	0.979	0.032	0.034	12:48:33 PM	4	10007
-10148.5607	3341.0791	1.96	2.378	0.923	1.05	0.032	0.034	12:48:34 PM	4	10007
-10148.5614	3341.0791	1.95	2.363	1.049	0.953	0.032	0.034	12:48:35 PM	4	10007
-10148.562	3341.079	1.97	2.419	0.993	1.024	0.032	0.034	12:48:36 PM	4	10007
-10148.5627	3341.079	1.99	2.376	0.964	1.01	0.032	0.034	12:48:37 PM	4	10007
-10148.5633	3341.079	1.95	2.387	1.002	1.048	0.032	0.034	12:48:38 PM	4	10007
-10148.564	3341.079	1.96	2.379	1.03	1.004	0.032	0.034	12:48:39 PM	4	10007
-10148.5646	3341.0789	1.91	2.406	0.935	1.036	0.032	0.034	12:48:40 PM	4	10007
-10148.5653	3341.0789	1.99	2.346	0.942	1.007	0.032	0.034	12:48:41 PM	4	10007
-10148.566	3341.0789	1.93	2.378	0.875	1.07	0.032	0.034	12:48:42 PM	4	10007
-10148.5665	3341.0789	1.44	2.37	0.976	1.019	0.032	0.034	12:48:43 PM	4	10007
-10148.5669	3341.0789	0.79	2.362	0.971	1.003	0.032	0.034	12:48:44 PM	4	10007
-10148.5672	3341.0789	0.9	2.372	0.986	0.993	0.032	0.034	12:48:45 PM	4	10007
-10148.5675	3341.0789	0.89	2.374	0.986	1.017	0.032	0.034	12:48:46 PM	4	10007
-10148.5678	3341.0789	0.89	2.368	0.981	1.004	0.032	0.034	12:48:47 PM	4	10007
-10148.5681	3341.0789	0.89	2.396	0.989	1.003	0.032	0.034	12:48:48 PM	4	10007
-10148.5684	3341.0789	0.87	2.399	0.94	0.994	0.032	0.034	12:48:49 PM	4	10007
-10148.5687	3341.0789	0.89	2.373	0.842	1.106	0.032	0.034	12:48:50 PM	4	10007
-10148.569	3341.0788	0.89	2.373	1.03	1.014	0.032	0.034	12:48:51 PM	4	10007
-10148.5692	3341.0788	0.24	2.381	0.955	1.006	0.032	0.034	12:48:52 PM	4	10007
-10148.5692	3341.0788	0.08	2.375	0.961	1.019	0.032	0.034	12:48:53 PM	4	10007
-10148.5692	3341.0788	0.09	2.386	1.001	1	0.032	0.034	12:48:54 PM	4	10007

Lat	long	Speed	Inclinometer	Load1	Load2	Yield1	Yield2	Time	Basket	Module
-10148.5692	3341.0789	0.08	2.373	0.969	1.008	0.032	0.034	12:48:55 PM	4	10007
-10148.5692	3341.0789	0.09	2.384	0.975	1.031	0.032	0.034	12:48:56 PM	4	10007
-10148.5692	3341.0789	0.1	2.372	1.002	1.014	0.032	0.034	12:48:57 PM	4	10007
-10148.5692	3341.0789	0.09	2.367	0.989	1.038	0.032	0.034	12:48:58 PM	4	10007
-10148.5692	3341.0789	0.01	2.385	0.982	1.025	0.032	0.034	12:48:59 PM	4	10007
-10148.5692	3341.0789	0.02	2.373	0.98	1.044	0.032	0.034	12:49:00 PM	4	10007
-10148.5692	3341.0789	0.03	2.377	0.997	1.049	0.032	0.034	12:49:01 PM	4	10007
-10148.5692	3341.0788	0.04	2.338	0.516	0.521	0.032	0.034	12:49:02 PM	4	10007
-10148.5692	3341.0788	0.04	2.156	0.513	0.517	0.032	0.034	12:49:03 PM	4	10007
-10148.5692	3341.0788	0.03	1.971	0.513	0.518	0.032	0.034	12:49:04 PM	4	10007
-10148.5692	3341.0788	0.02	1.805	0.517	0.519	0.032	0.034	12:49:05 PM	4	10007
-10148.5692	3341.0788	0.06	1.767	0.517	0.519	0.032	0.034	12:49:06 PM	4	10007
-10148.5692	3341.0788	0.07	1.659	0.515	0.519	0.032	0.034	12:49:07 PM	4	10007
-10148.5692	3341.0788	0.07	1.649	0.514	0.519	0.032	0.034	12:49:08 PM	4	10007
-10148.5691	3341.0788	0.07	1.642	0.517	0.52	0.032	0.034	12:49:09 PM	4	10007
-10148.5691	3341.0788	0.08	1.637	0.515	0.517	0.032	0.034	12:49:10 PM	4	10007
-10148.5691	3341.0788	0.02	1.636	0.514	0.519	0.032	0.034	12:49:11 PM	4	10007
-10148.5691	3341.0788	0.02	1.639	0.517	0.519	0.032	0.034	12:49:12 PM	4	10007
-10148.5691	3341.0788	0.03	1.64	0.515	0.52	0.032	0.034	12:49:13 PM	4	10007
-10148.5691	3341.0788	0.02	1.64	0.514	0.519	0.032	0.034	12:49:14 PM	4	10007
-10148.5691	3341.0788	0.02	1.638	0.518	0.52	0.032	0.034	12:49:15 PM	4	10007
-10148.5691	3341.0787	0.05	1.638	0.516	0.519	0.032	0.034	12:49:16 PM	4	10007
-10148.5691	3341.0787	0.02	1.64	0.514	0.52	0.032	0.034	12:49:17 PM	4	10007
-10148.5691	3341.0787	0.08	1.642	0.515	0.521	0.032	0.034	12:49:18 PM	4	10007
-10148.5691	3341.0787	0.09	1.638	0.516	0.518	0.032	0.034	12:49:19 PM	4	10007
-10148.5691	3341.0787	0.06	1.638	0.515	0.519	0.032	0.034	12:49:20 PM	4	10007

Lat	long	Speed	Inclinometer	Load1	Load2	Yield1	Yield2	Time	Basket	Module
-10148.5691	3341.0787	0.09	1.539	0.515	0.52	0.032	0.034	12:49:21 PM	4	10007
-10148.5691	3341.0788	0.1	1.389	0.516	0.519	0.032	0.034	12:49:22 PM	4	10007
-10148.5691	3341.0788	0.055	1.225	0.516	0.522	0.032	0.034	12:49:23 PM	4	10007
-10148.5691	3341.0787	0.01	1.044	0.518	0.52	0.032	0.034	12:49:24 PM	4	10007
-10148.5691	3341.0787	0.03	0.918	0.515	0.52	0.032	0.034	12:49:25 PM	4	10007
-10148.5691	3341.0787	0.03	0.7	0.52	0.52	0.032	0.034	12:49:26 PM	4	10007
-10148.5691	3341.0787	0.03	0.509	0.515	0.52	0.032	0.034	12:49:27 PM	4	10007
-10148.5691	3341.0786	0.08	0.307	0.515	0.519	0.032	0.034	12:49:28 PM	4	10007
-10148.5691	3341.0786	0.05	0.09	0.517	0.519	0.032	0.034	12:49:29 PM	4	10007
-10148.5691	3341.0786	0.07	0	0.519	0.522	0.032	0.034	12:49:30 PM	4	10007
-10148.5691	3341.0786	0.06	0.107	0.519	0.521	0.032	0.034	12:49:31 PM	4	10007
-10148.5691	3341.0786	0.07	0.358	0.517	0.519	0.032	0.034	12:49:32 PM	4	10007
-10148.5691	3341.0786	0.05	0.29	0.515	0.519	0.032	0.034	12:49:33 PM	4	10007
-10148.5691	3341.0787	0.07	2.391	0.887	0.725	0.032	0.034	12:54:57 PM	5	10007
-10148.6152	3341.099	0.09	2.391	0.969	0.648	0.032	0.034	12:54:58 PM	5	10007
-10148.6153	3341.099	0.08	2.435	0.999	0.633	0.032	0.034	12:54:59 PM	5	10007
-10148.6151	3341.099	1.21	2.337	0.903	0.707	0.032	0.034	12:55:00 PM	5	10007
-10148.6144	3341.099	2.88	2.245	0.956	0.635	0.032	0.034	12:55:01 PM	5	10007
-10148.6135	3341.0991	2.89	2.345	0.925	0.68	0.032	0.034	12:55:02 PM	5	10007
-10148.6126	3341.0991	2.58	2.319	0.916	0.697	0.032	0.034	12:55:03 PM	5	10007
-10148.6117	3341.0991	2.66	2.221	1.01	0.652	0.032	0.034	12:55:04 PM	5	10007
-10148.6109	3341.0991	2.57	2.297	0.834	0.704	0.032	0.034	12:55:05 PM	5	10007
-10148.61	3341.099	2.74	2.388	0.823	0.765	0.032	0.034	12:55:06 PM	5	10007
-10148.6091	3341.0991	2.72	2.334	0.853	0.721	0.032	0.034	12:55:07 PM	5	10007
-10148.6082	3341.0991	2.67	2.438	0.905	0.732	0.032	0.034	12:55:08 PM	5	10007
-10148.6073	3341.0991	2.68	2.395	0.884	0.737	0.032	0.034	12:55:09 PM	5	10007

Lat	long	Speed	Inclinometer	Load1	Load2	Yield1	Yield2	Time	Basket	Module
-10148.6064	3341.0991	2.67	2.383	0.905	0.712	0.032	0.034	12:55:10 PM	5	10007
-10148.6056	3341.0991	2.55	2.386	0.955	0.682	0.032	0.034	12:55:11 PM	5	10007
-10148.6047	3341.0991	2.59	2.383	0.914	0.711	0.032	0.034	12:55:12 PM	5	10007
-10148.6039	3341.0991	2.57	2.376	0.898	0.722	0.032	0.034	12:55:13 PM	5	10007
-10148.603	3341.0991	2.59	2.378	0.896	0.708	0.032	0.034	12:55:14 PM	5	10007
-10148.6022	3341.0991	2.56	2.404	0.905	0.733	0.032	0.034	12:55:15 PM	5	10007
-10148.6013	3341.0991	2.63	2.372	0.85	0.743	0.032	0.034	12:55:16 PM	5	10007
-10148.6005	3341.0992	2.69	2.366	0.912	0.724	0.032	0.034	12:55:17 PM	5	10007
-10148.5996	3341.0992	2.67	2.357	0.884	0.696	0.032	0.034	12:55:18 PM	5	10007
-10148.5987	3341.0992	2.64	2.378	0.9	0.697	0.032	0.034	12:55:19 PM	5	10007
-10148.5978	3341.0992	2.66	2.363	0.894	0.719	0.032	0.034	12:55:20 PM	5	10007
-10148.5969	3341.0992	2.69	2.319	0.886	0.692	0.032	0.034	12:55:21 PM	5	10007
-10148.5961	3341.0992	2.66	2.306	0.867	0.707	0.032	0.034	12:55:22 PM	5	10007
-10148.5952	3341.0992	2.61	2.353	0.863	0.741	0.032	0.034	12:55:23 PM	5	10007
-10148.5943	3341.0992	2.69	2.388	0.981	0.697	0.032	0.034	12:55:24 PM	5	10007
-10148.5935	3341.0992	2.67	2.392	0.915	0.703	0.032	0.034	12:55:25 PM	5	10007
-10148.5926	3341.0992	2.67	2.353	0.935	0.705	0.032	0.034	12:55:26 PM	5	10007
-10148.5917	3341.0993	2.71	2.351	0.893	0.72	0.032	0.034	12:55:27 PM	5	10007
-10148.5908	3341.0993	2.74	2.354	0.88	0.722	0.032	0.034	12:55:28 PM	5	10007
-10148.5899	3341.0993	2.76	2.405	0.897	0.743	0.032	0.034	12:55:29 PM	5	10007
-10148.589	3341.0993	2.79	2.375	0.954	0.712	0.032	0.034	12:55:30 PM	5	10007
-10148.5881	3341.0993	2.74	2.427	0.844	0.724	0.032	0.034	12:55:31 PM	5	10007
-10148.5872	3341.0993	2.72	2.421	0.886	0.732	0.032	0.034	12:55:32 PM	5	10007
-10148.5863	3341.0993	2.72	2.416	0.863	0.726	0.032	0.034	12:55:33 PM	5	10007
-10148.5854	3341.0993	2.66	2.363	0.901	0.726	0.032	0.034	12:55:34 PM	5	10007
-10148.5845	3341.0993	2.64	2.291	0.824	0.703	0.032	0.034	12:55:35 PM	5	10007

Lat	long	Speed	Inclinometer	Load1	Load2	Yield1	Yield2	Time	Basket	Module
-10148.5836	3341.0993	2.67	2.334	0.957	0.7	0.032	0.034	12:55:36 PM	5	10007
-10148.5828	3341.0993	2.67	2.342	0.947	0.696	0.032	0.034	12:55:37 PM	5	10007
-10148.5819	3341.0993	2.67	2.445	0.971	0.72	0.032	0.034	12:55:38 PM	5	10007
-10148.581	3341.0994	2.66	2.424	0.89	0.735	0.032	0.034	12:55:39 PM	5	10007
-10148.5801	3341.0994	2.7	2.393	0.915	0.751	0.032	0.034	12:55:40 PM	5	10007
-10148.5792	3341.0994	2.76	2.393	0.891	0.72	0.032	0.034	12:55:41 PM	5	10007
-10148.5783	3341.0994	2.75	2.415	0.886	0.729	0.032	0.034	12:55:42 PM	5	10007
-10148.5774	3341.0994	2.76	2.417	0.919	0.739	0.032	0.034	12:55:43 PM	5	10007
-10148.5765	3341.0994	2.76	2.408	0.88	0.74	0.032	0.034	12:55:44 PM	5	10007

APPENDIX E

OVERALL TESTING – SAMPLE DATA

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.28491	0.035	0.007	0.004	0.169	0.5	3.289	1
-97.3218	30.28491	0.035	0.008	0.004	0.38	0.506	3.29	1
-97.3218	30.28491	0.035	0.008	0.004	0.492	0.501	3.285	1
-97.3218	30.28491	0.115	0.007	0.004	0.506	0.499	3.285	1
-97.3218	30.28491	0.092	0.007	0.004	0.494	0.504	3.294	1
-97.3218	30.28491	0.058	0.007	0.004	0.497	0.501	3.286	1
-97.3218	30.28491	0.023	0.007	0.004	0.499	0.501	3.286	1
-97.3218	30.28491	0.081	0.007	0.004	0.502	0.503	3.292	1
-97.3218	30.28491	0.081	0.007	0.004	0.507	0.5	3.767	1
-97.3218	30.28491	0.069	0.007	0.004	0.502	0.513	3.775	1
-97.3218	30.28491	0.035	0.007	0.004	0.494	0.5	2.362	1
-97.3218	30.28491	0.069	0.008	0.004	0.502	0.507	1.432	1
-97.3218	30.28491	0.104	0.007	0.004	0.489	0.492	1.675	1
-97.3218	30.28491	0.081	0.007	0.004	0.5	0.501	1.307	1
-97.3218	30.28491	0.069	0.007	0.004	0.499	0.5	1.383	1
-97.3218	30.28491	0.035	0.007	0.004	0.503	0.5	1.392	1
-97.3218	30.28491	0.035	0.007	0.004	0.501	0.499	1.496	1
-97.3218	30.28491	0.092	0.007	0.004	0.503	0.503	1.629	1
-97.3218	30.28491	0.046	0.008	0.004	0.503	0.496	1.655	1
-97.3218	30.28491	0.046	0.007	0.004	0.499	0.507	1.67	1
-97.3218	30.28491	0.058	0.007	0.004	0.504	0.501	1.662	1
-97.3218	30.28491	0.104	0.007	0.004	0.506	0.506	1.67	1
-97.3218	30.28491	0.115	0.008	0.004	0.503	0.5	1.378	1
-97.3218	30.28491	0.069	0.007	0.004	0.495	0.499	0.442	1
-97.3218	30.2849	0.081	0.008	0.004	0.499	0.503	2.055	1
-97.3218	30.2849	0.035	0.007	0.004	0.493	0.506	2.143	1
-97.3218	30.2849	0.081	0.007	0.004	0.5	0.498	1.042	1
-97.3218	30.2849	0.104	0.007	0.004	0.502	0.5	1.057	1
-97.3218	30.2849	0.069	0.007	0.004	0.5	0.5	1.07	1
-97.3218	30.28489	0.207	0.007	0.004	0.497	0.501	2.106	1
-97.3218	30.28489	0.127	0.007	0.004	0.494	0.503	1.734	1
-97.3218	30.28489	0.115	0.007	0.004	0.502	0.504	1.45	1
-97.3218	30.28489	0.253	0.007	0.004	0.502	0.499	2.518	1
-97.3218	30.28489	0.115	0.007	0.004	0.499	0.503	2.866	1
-97.3218	30.28489	0.092	0.007	0.004	0.508	0.494	2.89	1
-97.3218	30.28489	0.069	0.007	0.004	0.506	0.503	2.899	1
-97.3218	30.28489	0.069	0.007	0.004	0.499	0.497	2.895	1
-97.3218	30.28489	0.069	0.007	0.004	0.494	0.498	2.919	1
-97.3218	30.28489	0.253	0.008	0.004	0.503	0.502	2.923	1

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.28489	0.081	0.008	0.004	0.5	0.499	2.923	1
-97.3218	30.28489	0.058	0.008	0.004	0.501	0.502	2.92	1
-97.3218	30.28489	0.127	0.008	0.004	0.501	0.499	2.922	1
-97.3218	30.28489	0.138	0.007	0.004	0.504	0.502	2.921	1
-97.3218	30.28489	0.138	0.007	0.004	0.502	0.499	2.934	1
-97.3218	30.28489	0.023	0.008	0.004	0.503	0.498	2.931	1
-97.3218	30.28489	0.161	0.007	0.004	0.505	0.498	2.934	1
-97.3218	30.28489	0.104	0.007	0.004	0.497	0.501	2.938	1
-97.3218	30.28489	0.081	0.007	0.004	0.509	0.508	2.93	1
-97.3218	30.28489	0.046	0.007	0.004	0.501	0.5	2.949	1
-97.3218	30.28489	0.023	0.007	0.003	0.497	0.508	2.949	1
-97.3218	30.28489	0.023	0.007	0.003	0.509	0.502	2.946	1
-97.3218	30.28489	0.196	0.007	0.003	0.499	0.507	2.958	1
-97.3218	30.28489	0.035	0.008	0.004	0.5	0.507	2.963	1
-97.3218	30.28489	0.081	0.007	0.003	0.507	0.498	2.963	1
-97.3218	30.28489	0.138	0.007	0.004	0.496	0.506	2.972	1
-97.3218	30.28489	0.161	0.007	0.004	0.505	0.504	2.97	1
-97.3218	30.28489	0.058	0.007	0.004	0.497	0.508	2.979	1
-97.3218	30.28489	0.046	0.008	0.004	0.492	0.496	2.986	1
-97.3218	30.28489	0.104	0.007	0.004	0.506	0.507	2.983	1
-97.3218	30.28489	0.081	0.008	0.004	0.499	0.493	2.99	1
-97.3218	30.2849	0.069	0.007	0.004	0.507	0.499	2.988	1
-97.3218	30.28489	0.023	0.008	0.004	0.497	0.504	2.986	1
-97.3218	30.28489	0.046	0.008	0.004	0.503	0.502	2.994	1
-97.3218	30.28489	0.104	0.008	0.004	0.504	0.508	2.995	1
-97.3218	30.28489	0.173	0.008	0.003	0.499	0.512	2.987	1
-97.3218	30.28489	0.069	0.008	0.004	0.501	0.5	2.991	1
-97.3218	30.28489	0.035	0.008	0.004	0.496	0.507	2.996	1
-97.3218	30.28489	0.092	0.008	0.004	0.503	0.504	3	1
-97.3218	30.28489	0.023	0.007	0.004	0.503	0.499	3.002	1
-97.3218	30.28489	0.046	0.008	0.004	0.504	0.502	3.007	1
-97.3218	30.28489	0.138	0.007	0.004	0.505	0.502	3.009	1
-97.3218	30.28489	0.092	0.007	0.004	0.5	0.498	3.001	1
-97.3218	30.28489	0.046	0.007	0.004	0.5	0.501	3.008	1
-97.3218	30.28489	0.023	0.007	0.004	0.495	0.501	3.005	1
-97.3218	30.28489	0.081	0.007	0.004	0.505	0.493	2.998	1
-97.3218	30.2849	0.104	0.007	0.004	0.504	0.503	3.014	1
-97.3218	30.2849	0.058	0.007	0.004	0.499	0.504	3.017	1
-97.3218	30.28489	0.196	0.007	0.004	0.499	0.503	3.018	1

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.28489	0.115	0.007	0.004	0.504	0.504	3.013	1
-97.3218	30.2849	0.069	0.007	0.004	0.496	0.509	3.021	1
-97.3218	30.2849	0.127	0.007	0.004	0.496	0.502	3.02	1
-97.3218	30.2849	0.161	0.007	0.004	0.498	0.494	3.023	1
-97.3218	30.28489	0.138	0.007	0.004	0.498	0.501	3.019	1
-97.3218	30.28489	0.127	0.007	0.004	0.5	0.515	3.03	1
-97.3218	30.28489	0.058	0.007	0.004	0.714	0.506	3.025	1
-97.3218	30.28489	0.104	0.008	0.004	0.551	0.503	3.012	1
-97.3218	30.28489	0.15	0.007	0.004	0.501	0.501	3.015	1
-97.3218	30.28489	0.069	0.007	0.004	0.499	0.497	3.026	1
-97.3218	30.28489	0.058	0.007	0.004	0.505	0.503	3.019	1
-97.3218	30.28489	0.035	0.007	0.004	0.501	0.502	3.024	1
-97.3218	30.28489	0.035	0.007	0.004	0.506	0.504	3.019	1
-97.3218	30.28489	0.035	0.007	0.004	0.507	0.496	3.021	1
-97.3218	30.28489	0.069	0.007	0.004	0.8	0.505	3.025	1
-97.3218	30.28489	0.035	0.007	0.004	0.886	0.504	3.029	1
-97.3218	30.28489	0.069	0.007	0.004	0.917	0.505	3.026	1
-97.3218	30.28489	0.081	0.007	0.004	0.93	0.509	3.019	1
-97.3218	30.28489	0.092	0.007	0.003	0.956	0.503	3.024	1
-97.3218	30.28489	0.15	0.007	0.004	1.01	0.499	3.026	1
-97.3218	30.28489	0.069	0.007	0.003	1.006	0.503	3.023	1
-97.3218	30.28489	0.138	0.007	0.003	1.019	0.503	3.031	1
-97.3218	30.28489	0.115	0.007	0.004	1.024	0.502	3.024	1
-97.3218	30.28489	0.092	0.007	0.003	1.011	0.501	3.028	1
-97.3218	30.28489	0.035	0.007	0.003	1.006	0.503	3.022	1
-97.3218	30.28489	0.058	0.007	0.003	0.994	0.506	3.029	1
-97.3218	30.2849	0.081	0.007	0.004	1.005	0.502	3.028	1
-97.3218	30.2849	0.046	0.007	0.004	1.141	0.5	3.025	1
-97.3218	30.2849	0.058	0.007	0.004	1.247	0.506	3.023	1
-97.3218	30.2849	0.127	0.007	0.004	1.299	0.507	3.022	1
-97.3218	30.2849	0.127	0.007	0.004	1.347	0.504	3.029	1
-97.3218	30.28491	0.081	0.007	0.004	1.386	0.499	3.024	1
-97.3218	30.28491	0.046	0.007	0.004	1.422	0.5	3.023	1
-97.3218	30.28491	0.058	0.007	0.004	1.444	0.505	3.028	1
-97.3218	30.28491	0.138	0.007	0.004	1.509	0.503	3.028	1
-97.3218	30.28491	0.046	0.007	0.004	1.551	0.504	3.034	1
-97.3218	30.28491	0.081	0.007	0.004	1.613	0.505	3.032	1
-97.3218	30.28491	0.012	0.008	0.004	1.649	0.505	3.028	1
-97.3218	30.28491	0.15	0.007	0.004	1.709	0.501	3.024	1

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.28491	0.069	0.007	0.004	1.751	0.505	3.028	1
-97.3218	30.28491	0.035	0.008	0.003	1.787	0.511	3.027	1
-97.3218	30.28491	0.012	0.007	0.004	1.826	0.506	3.031	1
-97.3218	30.28491	0.104	0.007	0.004	1.857	0.508	3.025	1
-97.3218	30.28491	0.058	0.007	0.004	1.887	0.502	3.029	1
-97.3218	30.2849	0.104	0.007	0.004	1.932	0.498	3.025	1
-97.3218	30.2849	0.127	0.007	0.004	1.967	0.503	3.027	1
-97.3218	30.2849	0.092	0.007	0.004	2.023	0.497	3.033	1
-97.3218	30.2849	0.138	0.008	0.004	2.06	0.511	3.031	1
-97.3218	30.2849	0.023	0.007	0.004	2.106	0.504	3.027	1
-97.3218	30.2849	0.046	0.007	0.004	2.116	0.511	3.024	1
-97.3218	30.2849	0.035	0.007	0.004	2.12	0.508	3.033	1
-97.3218	30.2849	0.035	0.007	0.004	2.114	0.505	3.034	1
-97.3218	30.2849	0.035	0.007	0.004	2.115	0.509	3.037	1
-97.3218	30.2849	0.046	0.007	0.004	2.106	0.507	3.039	1
-97.3218	30.2849	0.173	0.007	0.004	2.087	0.508	3.039	1
-97.3218	30.2849	0.035	0.007	0.004	2.088	0.501	3.037	1
-97.3218	30.2849	0.161	0.007	0.004	2.093	0.504	3.032	1
-97.3218	30.2849	0.161	0.007	0.004	2.248	0.508	3.029	1
-97.3218	30.2849	0.058	0.007	0.004	2.351	0.502	3.032	1
-97.3218	30.2849	0.058	0.007	0.004	2.444	0.505	3.035	1
-97.3218	30.2849	0.058	0.007	0.004	2.546	0.506	3.026	1
-97.3218	30.2849	0.012	0.007	0.004	2.639	0.507	3.028	1
-97.3218	30.2849	0.058	0.008	0.004	2.698	0.511	3.037	1
-97.3218	30.2849	0.092	0.007	0.004	2.747	0.506	3.033	1
-97.3218	30.2849	0.058	0.007	0.004	2.739	0.505	3.035	1
-97.3218	30.2849	0.023	0.008	0.004	2.736	0.511	3.036	1
-97.3218	30.2849	0.092	0.007	0.004	2.727	0.509	3.039	1
-97.3218	30.2849	0.023	0.007	0.004	2.719	0.504	2.976	1
-97.3218	30.2849	0.138	0.007	0.004	2.706	0.504	0.838	1
-97.3218	30.2849	0.115	0.007	0.004	2.694	0.502	1.156	1
-97.3218	30.2849	0.276	0.007	0.004	2.689	0.506	1.553	1
-97.3218	30.2849	0.092	0.007	0.004	2.68	0.505	1.02	1
-97.3218	30.2849	0.104	0.007	0.004	2.683	0.504	1.012	1
-97.3218	30.2849	0.046	0.007	0.004	2.669	0.506	0.875	1
-97.3218	30.2849	0.058	0.007	0.004	2.679	0.507	0.921	1
-97.3218	30.2849	0.035	0.007	0.004	2.651	0.503	2.395	1
-97.3218	30.2849	0.127	0.007	0.004	2.659	0.505	2.491	1
-97.3218	30.2849	0.035	0.007	0.004	2.651	0.507	2.19	1

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.127	0.007	0.004	2.644	0.501	1.846	1
-97.3218	30.2849	0.058	0.008	0.004	2.632	0.497	2.015	1
-97.3218	30.2849	0.092	0.007	0.004	2.623	0.508	2.029	1
-97.3218	30.2849	0.173	0.008	0.004	2.63	0.502	2.083	1
-97.3218	30.2849	0.058	0.007	0.004	2.62	0.502	2.089	1
-97.3218	30.2849	0.127	0.008	0.004	2.623	0.502	2.09	1
-97.3218	30.2849	0.058	0.008	0.004	2.617	0.505	2.08	1
-97.3218	30.2849	0.081	0.008	0.004	2.604	0.506	2.102	1
-97.3218	30.2849	0.15	0.007	0.004	2.61	0.501	2.128	1
-97.3218	30.2849	0.023	0.008	0.004	2.598	0.503	2.093	1
-97.3218	30.2849	0.046	0.008	0.004	2.596	0.508	1.955	1
-97.3218	30.2849	0.058	0.007	0.004	0.5	0.504	1.422	1
-97.3218	30.2849	0.104	0.007	0.004	0.5	0.502	1.097	1
-97.3218	30.2849	0.115	0.007	0.004	0.489	0.503	0.944	1
-97.3218	30.2849	0.069	0.007	0.004	0.493	0.502	1.011	1
-97.3218	30.2849	0.046	0.007	0.004	0.5	0.502	0.993	1
-97.3218	30.2849	0.023	0.007	0.003	0.501	0.502	0.894	1
-97.3218	30.2849	0.058	0.007	0.004	0.502	0.507	0.733	1
-97.3218	30.2849	0.058	0.007	0.004	0.498	0.503	0.287	1
-97.3218	30.2849	0.092	0.007	0.004	0.493	0.501	0.265	1
-97.3218	30.2849	0.069	0.007	0.004	0.498	0.501	0.191	1
-97.3218	30.2849	0.092	0.007	0.004	0.495	0.501	0.177	1
-97.3218	30.2849	0.15	0.007	0.004	0.5	0.504	0.173	2
-97.3218	30.2849	0.058	0.007	0.004	0.493	0.509	0.174	2
-97.3218	30.2849	0.081	0.007	0.004	0.498	0.5	0.164	2
-97.3218	30.2849	0.081	0.007	0.004	0.491	0.5	0.168	2
-97.3218	30.2849	0.023	0.007	0.004	0.494	0.505	0.17	2
-97.3218	30.2849	0.058	0.007	0.004	0.495	0.505	0.189	2
-97.3218	30.2849	0.023	0.007	0.004	0.496	0.508	0.256	2
-97.3218	30.2849	0.035	0.007	0.004	0.505	0.504	0.556	2
-97.3218	30.2849	0.046	0.007	0.004	0.499	0.507	0.756	2
-97.3218	30.2849	0.058	0.007	0.004	0.506	0.501	0.986	2
-97.3218	30.2849	0.092	0.007	0.004	0.497	0.5	1.397	2
-97.3218	30.2849	0.104	0.007	0.004	0.501	0.499	1.874	2
-97.3218	30.2849	0.069	0.007	0.004	0.501	0.499	2.156	2
-97.3218	30.2849	0.092	0.007	0.004	0.491	0.504	2.546	2
-97.3218	30.2849	0.035	0.007	0.004	0.5	0.5	2.524	2
-97.3218	30.2849	0.069	0.007	0.004	0.5	0.507	2.475	2
-97.3218	30.2849	0.058	0.007	0.004	0.59	0.502	2.576	2

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.15	0.007	0.004	1.382	0.508	2.55	2
-97.3218	30.2849	0.035	0.007	0.004	1.772	0.502	2.546	2
-97.3218	30.2849	0.115	0.007	0.003	1.842	0.501	2.524	2
-97.3218	30.2849	0.092	0.007	0.004	1.962	0.501	2.532	2
-97.3218	30.2849	0.046	0.007	0.004	1.993	0.503	2.532	2
-97.3218	30.2849	0.012	0.007	0.004	1.986	0.503	2.414	2
-97.3218	30.2849	0.173	0.007	0.004	2.048	0.504	2.455	2
-97.3218	30.2849	0.161	0.007	0.004	2.041	0.502	2.475	2
-97.3218	30.2849	0.069	0.007	0.004	2.043	0.502	2.488	2
-97.3218	30.2849	0.058	0.007	0.004	2.047	0.498	2.566	2
-97.3218	30.2849	0.058	0.007	0.004	2.042	0.504	2.637	2
-97.3218	30.2849	0.069	0.007	0.004	2.041	0.506	2.265	2
-97.3218	30.2849	0.104	0.007	0.004	2.034	0.504	2.414	2
-97.3218	30.2849	0.023	0.008	0.004	2.033	0.501	2.268	2
-97.3218	30.2849	0.069	0.007	0.004	2.036	0.507	2.275	2
-97.3218	30.2849	0.035	0.007	0.004	2.034	0.503	2.267	2
-97.3218	30.2849	0.115	0.008	0.004	2.032	0.507	2.282	2
-97.3218	30.2849	0.127	0.007	0.004	2.03	0.499	2.277	2
-97.3218	30.2849	0.023	0.008	0.004	2.028	0.5	2.296	2
-97.3218	30.2849	0.104	0.008	0.004	2.027	0.509	2.33	2
-97.3218	30.2849	0.092	0.008	0.004	2.039	0.509	2.298	2
-97.3218	30.2849	0.046	0.008	0.004	2.021	0.502	2.281	2
-97.3218	30.2849	0.104	0.008	0.004	2.032	0.506	2.298	2
-97.3218	30.2849	0.046	0.008	0.003	2.019	0.503	2.289	2
-97.3218	30.2849	0.035	0.008	0.004	2.027	0.506	2.297	2
-97.3218	30.2849	0.138	0.008	0.004	2.025	0.499	2.323	2
-97.3218	30.2849	0.115	0.008	0.004	2.021	0.503	2.274	2
-97.3218	30.2849	0.069	0.007	0.004	2.022	0.509	2.292	2
-97.3218	30.2849	0.035	0.007	0.004	2.016	0.503	2.315	2
-97.3218	30.2849	0.058	0.008	0.004	2.019	0.504	2.314	2
-97.3218	30.2849	0.138	0.008	0.004	2.024	0.503	2.331	2
-97.3218	30.2849	0.058	0.007	0.004	2.016	0.51	2.343	2
-97.3218	30.2849	0.058	0.007	0.004	2.02	0.499	2.36	2
-97.3218	30.2849	0.127	0.007	0.004	2.017	0.5	2.367	2
-97.3218	30.2849	0.023	0.007	0.004	2.019	0.508	2.332	2
-97.3218	30.2849	0.046	0.007	0.004	2.016	0.501	2.381	2
-97.3218	30.2849	0.081	0.008	0.003	2.015	0.507	2.282	2
-97.3218	30.2849	0.046	0.007	0.003	2.014	0.502	1.981	2
-97.3218	30.2849	0.035	0.007	0.003	0.497	0.498	2.058	2

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.046	0.007	0.004	0.504	0.501	1.13	2
-97.3218	30.2849	0.046	0.007	0.004	0.494	0.503	0.8	2
-97.3218	30.2849	0.069	0.007	0.004	0.497	0.498	0.717	2
-97.3218	30.2849	0.069	0.007	0.004	0.498	0.499	0.707	2
-97.3218	30.2849	0.069	0.007	0.004	0.489	0.495	0.722	2
-97.3218	30.2849	0.081	0.007	0.004	0.491	0.503	0.725	2
-97.3218	30.2849	0.035	0.007	0.004	0.507	0.501	0.716	2
-97.3218	30.2849	0.104	0.007	0.004	0.5	0.501	0.725	2
-97.3218	30.2849	0.035	0.007	0.004	0.498	0.504	0.726	2
-97.3218	30.2849	0.069	0.007	0.004	0.498	0.508	0.727	2
-97.3218	30.2849	0.115	0.007	0.004	0.499	0.509	0.714	3
-97.3218	30.2849	0.058	0.007	0.004	0.497	0.5	0.712	3
-97.3218	30.2849	0.104	0.007	0.004	0.495	0.502	0.749	3
-97.3218	30.2849	0.081	0.007	0.004	0.501	0.505	0.929	3
-97.3218	30.2849	0.058	0.007	0.004	0.499	0.507	1.111	3
-97.3218	30.2849	0.092	0.007	0.004	0.498	0.506	1.302	3
-97.3218	30.2849	0.058	0.007	0.004	0.495	0.507	2.383	3
-97.3218	30.2849	0.081	0.007	0.004	0.494	0.498	2.506	3
-97.3218	30.2849	0.081	0.007	0.004	0.499	0.501	2.603	3
-97.3218	30.2849	0.184	0.007	0.004	0.505	0.501	2.727	3
-97.3218	30.2849	0.035	0.007	0.004	0.499	0.503	2.737	3
-97.3218	30.2849	0.115	0.007	0.004	0.498	0.5	2.725	3
-97.3218	30.2849	0.081	0.007	0.004	0.494	0.497	2.495	3
-97.3218	30.2849	0.069	0.008	0.004	0.496	0.504	2.391	3
-97.3218	30.2849	0.023	0.007	0.004	0.497	0.505	2.245	3
-97.3218	30.2849	0.104	0.007	0.004	0.502	0.499	2.221	3
-97.3218	30.2849	0.161	0.008	0.004	0.499	0.505	2.154	3
-97.3218	30.2849	0.115	0.007	0.004	0.759	0.5	2.226	3
-97.3218	30.2849	0.069	0.007	0.004	0.978	0.496	2.24	3
-97.3218	30.2849	0.207	0.007	0.004	1.104	0.509	2.236	3
-97.3218	30.2849	0.081	0.007	0.004	1.168	0.506	2.245	3
-97.3218	30.2849	0.081	0.007	0.005	1.223	0.501	2.181	3
-97.3218	30.2849	0.058	0.007	0.004	1.224	0.507	2.225	3
-97.3218	30.2849	0.058	0.007	0.004	1.326	0.499	2.154	3
-97.3218	30.2849	0.196	0.007	0.004	1.485	0.502	2.146	3
-97.3218	30.2849	0.046	0.008	0.004	1.532	0.497	2.168	3
-97.3218	30.2849	0.104	0.007	0.003	1.657	0.502	2.16	3
-97.3218	30.2849	0.058	0.007	0.004	1.818	0.504	2.152	3
-97.3218	30.2849	0.104	0.007	0.003	2.004	0.503	2.105	3

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.161	0.008	0.004	2.106	0.502	2.082	3
-97.3218	30.2849	0.104	0.008	0.004	2.224	0.505	2.098	3
-97.3218	30.2849	0.081	0.008	0.004	2.368	0.5	2.091	3
-97.3218	30.2849	0.15	0.007	0.004	2.462	0.502	2.098	3
-97.3218	30.2849	0.069	0.008	0.004	2.566	0.503	2.115	3
-97.3218	30.2849	0.081	0.008	0.004	2.669	0.504	2.082	3
-97.3218	30.2849	0.058	0.007	0.004	2.67	0.496	2.077	3
-97.3218	30.2849	0.184	0.007	0.004	2.661	0.507	2.115	3
-97.3218	30.2849	0.023	0.007	0.004	2.672	0.505	2.19	3
-97.3218	30.2849	0.046	0.007	0.004	2.655	0.51	2.138	3
-97.3218	30.2849	0.127	0.007	0.004	2.659	0.503	1.936	3
-97.3218	30.2849	0.035	0.007	0.004	2.658	0.501	1.953	3
-97.3218	30.2849	0.104	0.007	0.004	2.648	0.504	1.941	3
-97.3218	30.2849	0.023	0.007	0.004	2.656	0.504	2.145	3
-97.3218	30.2849	0.046	0.007	0.004	2.648	0.506	2.261	3
-97.3218	30.2849	0.081	0.007	0.004	2.642	0.502	1.964	3
-97.3218	30.2849	0.046	0.007	0.004	2.65	0.508	2.689	3
-97.3218	30.2849	0.138	0.007	0.004	2.651	0.505	2.369	3
-97.3218	30.2849	0.104	0.007	0.004	2.652	0.506	2.229	3
-97.3218	30.2849	0.104	0.007	0.004	2.643	0.51	2.291	3
-97.3218	30.2849	0.023	0.007	0.004	2.64	0.51	2.109	3
-97.3218	30.2849	0.138	0.007	0.004	2.645	0.505	1.751	3
-97.3218	30.2849	0.058	0.007	0.004	2.647	0.511	1.834	3
-97.3218	30.2849	0.092	0.007	0.004	2.649	0.508	1.833	3
-97.3218	30.2849	0.035	0.007	0.004	2.641	0.505	1.636	3
-97.3218	30.2849	0.138	0.008	0.004	2.642	0.505	2.279	3
-97.3218	30.2849	0.035	0.007	0.004	2.639	0.507	2.204	3
-97.3218	30.2849	0.046	0.007	0.004	2.639	0.505	2.1	3
-97.3218	30.2849	0.058	0.007	0.004	2.641	0.508	2.245	3
-97.3218	30.2849	0.138	0.007	0.004	2.642	0.504	2.243	3
-97.3218	30.2849	0.069	0.008	0.004	2.64	0.5	2.276	3
-97.3218	30.2849	0.115	0.007	0.004	2.638	0.501	2.256	3
-97.3218	30.2849	0.046	0.007	0.004	2.639	0.505	2.275	3
-97.3218	30.2849	0.081	0.007	0.004	2.641	0.511	2.461	3
-97.3218	30.2849	0.104	0.007	0.004	2.639	0.508	2.407	3
-97.3218	30.2849	0.092	0.007	0.004	0.927	0.503	0.916	3
-97.3218	30.2849	0.092	0.007	0.004	0.506	0.503	1.202	3
-97.3218	30.2849	0.104	0.007	0.004	0.497	0.504	1.304	3
-97.3218	30.2849	0.138	0.007	0.004	0.501	0.503	0.979	3

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.046	0.007	0.004	0.493	0.5	0.991	3
-97.3218	30.2849	0.173	0.007	0.004	0.502	0.505	0.91	3
-97.3218	30.2849	0.15	0.007	0.004	0.5	0.502	1.01	3
-97.3218	30.2849	0.058	0.007	0.004	0.507	0.5	0.966	3
-97.3218	30.2849	0.115	0.007	0.004	0.497	0.507	1.02	3
-97.3218	30.2849	0.035	0.007	0.004	0.501	0.51	1.064	3
-97.3218	30.2849	0.069	0.007	0.004	0.488	0.5	1.101	3
-97.3218	30.2849	0.081	0.007	0.004	0.5	0.507	1.119	3
-97.3218	30.2849	0.104	0.007	0.004	0.5	0.505	1.165	3
-97.3218	30.2849	0.081	0.007	0.004	0.499	0.506	1.124	4
-97.3218	30.2849	0.023	0.007	0.004	0.498	0.501	1.162	4
-97.3218	30.2849	0.069	0.007	0.004	0.504	0.508	1.799	4
-97.3218	30.2849	0.035	0.007	0.004	0.495	0.498	2.517	4
-97.3218	30.2849	0.058	0.007	0.004	0.501	0.505	2.763	4
-97.3218	30.2849	0.081	0.007	0.004	1.131	0.501	2.496	4
-97.3218	30.2849	0.138	0.007	0.004	1.106	0.503	2.403	4
-97.3218	30.2849	0.127	0.007	0.004	1.167	0.504	2.407	4
-97.3218	30.2849	0.058	0.007	0.004	1.181	0.503	2.488	4
-97.3218	30.2849	0.046	0.006	0.004	1.154	0.499	2.691	4
-97.3218	30.2849	0.138	0.007	0.004	1.131	0.508	2.588	4
-97.3218	30.2849	0.035	0.007	0.004	1.106	0.495	2.497	4
-97.3218	30.2849	0.046	0.007	0.004	1.074	0.505	2.391	4
-97.3218	30.2849	0.092	0.007	0.004	1.045	0.507	2.378	4
-97.3218	30.2849	0.046	0.007	0.004	1.026	0.505	2.384	4
-97.3218	30.2849	0.069	0.007	0.004	1.005	0.501	2.43	4
-97.3218	30.2849	0.069	0.007	0.004	0.983	0.501	2.413	4
-97.3218	30.2849	0.092	0.007	0.004	0.946	0.5	2.385	4
-97.3218	30.2849	0.104	0.007	0.004	0.931	0.494	2.191	4
-97.3218	30.2849	0.069	0.007	0.004	0.913	0.503	2.227	4
-97.3218	30.2849	0.104	0.007	0.004	0.892	0.504	2.271	4
-97.3218	30.2849	0.058	0.007	0.004	0.873	0.502	2.287	4
-97.3218	30.2849	0.069	0.007	0.004	0.856	0.5	2.276	4
-97.3218	30.2849	0.115	0.007	0.004	0.835	0.502	2.282	4
-97.3218	30.2849	0.127	0.007	0.004	0.818	0.501	2.295	4
-97.3218	30.2849	0.104	0.007	0.004	0.799	0.509	2.293	4
-97.3218	30.2849	0.069	0.007	0.004	0.783	0.497	2.289	4
-97.3218	30.2849	0.092	0.007	0.004	0.771	0.5	2.281	4
-97.3218	30.2849	0.092	0.007	0.004	0.756	0.506	2.286	4
-97.3218	30.2849	0.069	0.007	0.004	0.743	0.503	2.289	4

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.058	0.007	0.004	0.725	0.501	2.283	4
-97.3218	30.2849	0.058	0.008	0.004	0.718	0.507	2.298	4
-97.3218	30.2849	0.104	0.007	0.004	0.694	0.497	2.293	4
-97.3218	30.2849	0.069	0.007	0.004	0.686	0.502	2.296	4
-97.3218	30.2849	0.092	0.007	0.004	0.684	0.494	2.187	4
-97.3218	30.2849	0.046	0.008	0.004	0.662	0.503	2.196	4
-97.3218	30.2849	0.115	0.007	0.004	0.647	0.5	2.183	4
-97.3218	30.2849	0.035	0.007	0.004	0.635	0.497	2.185	4
-97.3218	30.2849	0.058	0.007	0.004	0.628	0.509	2.185	4
-97.3218	30.2849	0.023	0.007	0.004	0.616	0.505	2.18	4
-97.3218	30.2849	0.127	0.008	0.004	0.606	0.501	2.184	4
-97.3218	30.2849	0.069	0.007	0.004	0.602	0.506	2.179	4
-97.3218	30.2849	0.104	0.007	0.004	0.587	0.51	2.221	4
-97.3218	30.2849	0.046	0.007	0.004	0.581	0.507	2.282	4
-97.3218	30.2849	0.069	0.007	0.004	0.571	0.499	2.264	4
-97.3218	30.2849	0.035	0.007	0.004	0.562	0.5	2.27	4
-97.3218	30.2849	0.069	0.007	0.004	0.553	0.499	2.281	4
-97.3218	30.2849	0.012	0.007	0.004	0.542	0.499	1.861	4
-97.3218	30.2849	0.058	0.007	0.004	0.501	0.501	1.29	4
-97.3218	30.2849	0.058	0.007	0.004	0.501	0.505	1.322	4
-97.3218	30.2849	0.058	0.007	0.004	0.498	0.5	1.385	4
-97.3218	30.2849	0.023	0.007	0.004	0.495	0.502	0.521	4
-97.3218	30.2849	0.046	0.007	0.004	0.5	0.501	0.136	4
-97.3218	30.2849	0.081	0.007	0.004	0.498	0.503	0.135	4
-97.3218	30.2849	0.092	0.007	0.004	0.497	0.502	0.225	4
-97.3218	30.2849	0.046	0.007	0.004	0.497	0.501	0.239	4
-97.3218	30.2849	0.035	0.007	0.004	0.496	0.501	0.265	4
-97.3218	30.2849	0.023	0.007	0.004	0.495	0.499	0.226	4
-97.3218	30.2849	0.081	0.007	0.004	0.498	0.501	0.038	4
-97.3218	30.2849	0.081	0.007	0.004	0.498	0.494	0.118	4
-97.3218	30.2849	0.023	0.007	0.004	0.492	0.507	0.064	4
-97.3218	30.2849	0.058	0.008	0.004	0.507	0.503	0.065	5
-97.3218	30.2849	0.15	0.007	0.004	0.496	0.509	0.052	5
-97.3218	30.2849	0.115	0.007	0.004	0.492	0.501	0.434	5
-97.3218	30.2849	0.081	0.007	0.004	0.499	0.505	2.121	5
-97.3218	30.2849	0.127	0.008	0.003	0.499	0.502	2.19	5
-97.3218	30.2849	0.058	0.008	0.004	0.492	0.504	2.201	5
-97.3218	30.2849	0.058	0.007	0.004	0.498	0.509	2.098	5
-97.3218	30.2849	0.092	0.007	0.004	0.504	0.504	2.092	5

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.058	0.008	0.004	0.494	0.498	2.126	5
-97.3218	30.2849	0.069	0.007	0.004	0.501	0.503	2.031	5
-97.3218	30.2849	0.127	0.007	0.004	0.503	0.501	1.922	5
-97.3218	30.2849	0.127	0.007	0.004	0.509	0.495	1.959	5
-97.3218	30.2849	0.092	0.007	0.004	0.504	0.499	1.769	5
-97.3218	30.2849	0.081	0.007	0.004	0.496	0.503	1.59	5
-97.3218	30.2849	0.104	0.007	0.004	0.504	0.505	1.73	5
-97.3218	30.2849	0.058	0.007	0.004	0.497	0.507	1.663	5
-97.3218	30.2849	0.081	0.007	0.004	0.499	0.505	1.684	5
-97.3218	30.2849	0.058	0.007	0.004	0.497	0.505	1.689	5
-97.3218	30.2849	0.012	0.007	0.004	0.5	0.498	1.691	5
-97.3218	30.2849	0.104	0.007	0.004	0.632	0.504	1.692	5
-97.3218	30.2849	0.127	0.007	0.004	0.686	0.501	1.69	5
-97.3218	30.2849	0.115	0.007	0.004	0.74	0.502	1.695	5
-97.3218	30.2849	0.046	0.007	0.004	0.805	0.504	1.663	5
-97.3218	30.2849	0.035	0.007	0.004	0.874	0.498	1.679	5
-97.3218	30.2849	0.161	0.007	0.004	0.929	0.505	1.674	5
-97.3218	30.2849	0.104	0.007	0.004	0.928	0.501	1.69	5
-97.3218	30.2849	0.046	0.007	0.004	0.926	0.5	1.712	5
-97.3218	30.2849	0.092	0.007	0.004	1.119	0.498	1.632	5
-97.3218	30.2849	0.046	0.007	0.004	1.202	0.505	1.613	5
-97.3218	30.2849	0.058	0.007	0.004	1.301	0.512	1.608	5
-97.3218	30.2849	0.046	0.006	0.004	1.441	0.505	1.572	5
-97.3218	30.2849	0.081	0.007	0.004	1.502	0.502	1.588	5
-97.3218	30.2849	0.058	0.007	0.004	1.59	0.5	1.589	5
-97.3218	30.2849	0.081	0.007	0.004	1.664	0.501	1.591	5
-97.3218	30.2849	0.069	0.007	0.004	1.713	0.508	1.585	5
-97.3218	30.2849	0.127	0.007	0.004	1.774	0.509	1.586	5
-97.3218	30.2849	0.104	0.007	0.004	1.83	0.507	1.582	5
-97.3218	30.2849	0.046	0.007	0.004	1.881	0.502	1.581	5
-97.3218	30.2849	0.058	0.007	0.004	1.923	0.502	1.605	5
-97.3218	30.2849	0.173	0.007	0.004	1.928	0.5	1.751	5
-97.3218	30.2849	0.069	0.007	0.004	1.926	0.499	1.681	5
-97.3218	30.2849	0.092	0.007	0.004	2.007	0.51	1.642	5
-97.3218	30.2849	0.104	0.007	0.004	2.122	0.501	1.668	5
-97.3218	30.2849	0.092	0.007	0.004	2.247	0.5	1.643	5
-97.3218	30.2849	0.092	0.008	0.004	2.339	0.507	1.634	5
-97.3218	30.2849	0.15	0.007	0.004	2.467	0.505	1.642	5
-97.3218	30.2849	0.127	0.007	0.004	2.615	0.5	1.643	5

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.173	0.008	0.004	2.642	0.495	1.72	5
-97.3218	30.2849	0.138	0.008	0.004	2.641	0.498	1.877	5
-97.3218	30.2849	0.046	0.008	0.004	2.645	0.501	1.622	5
-97.3218	30.2849	0.012	0.008	0.004	2.636	0.507	1.479	5
-97.3218	30.2849	0.046	0.007	0.004	2.637	0.499	1.37	5
-97.3218	30.2849	0.035	0.008	0.004	2.634	0.506	1.442	5
-97.3218	30.2849	0.092	0.008	0.004	2.644	0.5	1.802	5
-97.3218	30.2849	0.161	0.008	0.004	2.632	0.502	1.672	5
-97.3218	30.2849	0.023	0.007	0.004	2.633	0.504	1.577	5
-97.3218	30.2849	0.115	0.007	0.004	0.5	0.498	0.418	5
-97.3218	30.2849	0.092	0.007	0.004	0.499	0.501	0.641	5
-97.3218	30.2849	0.115	0.007	0.004	0.505	0.503	0.669	5
-97.3218	30.2849	0.035	0.007	0.004	0.503	0.504	0.724	5
-97.3218	30.2849	0.15	0.007	0.004	0.501	0.508	0.744	5
-97.3218	30.2849	0.184	0.007	0.004	0.499	0.498	0.738	5
-97.3218	30.2849	0.069	0.007	0.004	0.501	0.499	0.745	5
-97.3218	30.2849	0.092	0.007	0.004	0.508	0.501	0.63	5
-97.3218	30.2849	0.104	0.007	0.004	0.498	0.503	0.629	5
-97.3218	30.2849	0.15	0.007	0.004	0.498	0.505	0.594	5
-97.3218	30.2849	0.069	0.007	0.004	0.499	0.502	0.603	6
-97.3218	30.2849	0.046	0.007	0.004	0.498	0.504	0.634	6
-97.3218	30.2849	0.081	0.007	0.004	0.497	0.506	0.627	6
-97.3218	30.2849	0.023	0.007	0.004	0.504	0.503	0.625	6
-97.3218	30.2849	0.104	0.007	0.004	0.499	0.508	0.634	6
-97.3218	30.2849	0.046	0.007	0.004	0.502	0.496	0.66	6
-97.3218	30.2849	0.196	0.007	0.004	0.488	0.505	0.681	6
-97.3218	30.2849	0.092	0.007	0.004	0.495	0.503	0.343	6
-97.3218	30.2849	0.242	0.007	0.004	0.497	0.5	0.478	6
-97.3218	30.2849	0.023	0.007	0.004	0.5	0.505	2.156	6
-97.3218	30.2849	0.081	0.008	0.004	0.857	0.498	2.37	6
-97.3218	30.2849	0.127	0.008	0.004	0.954	0.504	2.281	6
-97.3218	30.2849	0.081	0.007	0.004	1.042	0.501	2.171	6
-97.3218	30.2849	0.184	0.008	0.004	1.26	0.501	2.194	6
-97.3218	30.2849	0.035	0.007	0.004	1.521	0.502	2.165	6
-97.3218	30.2849	0.196	0.007	0.004	1.562	0.504	2.141	6
-97.3218	30.2849	0.299	0.007	0.004	1.575	0.506	2.157	6
-97.3218	30.2849	0.081	0.007	0.004	1.575	0.508	2.147	6
-97.3218	30.2849	0.104	0.007	0.004	1.579	0.5	2.228	6
-97.3218	30.2849	0.138	0.007	0.004	1.688	0.505	2.158	6

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.081	0.007	0.004	1.765	0.503	2.176	6
-97.3218	30.2849	0.15	0.007	0.004	1.762	0.502	2.21	6
-97.3218	30.2849	0.115	0.007	0.004	1.763	0.503	2.211	6
-97.3218	30.2849	0.058	0.007	0.004	1.767	0.505	2.212	6
-97.3218	30.2849	0.081	0.006	0.004	1.75	0.501	2.285	6
-97.3218	30.2849	0.184	0.006	0.004	1.762	0.509	2.345	6
-97.3218	30.2849	0.196	0.007	0.004	1.757	0.503	2.338	6
-97.3218	30.2849	0.023	0.007	0.004	1.759	0.503	2.036	6
-97.3218	30.2849	0.081	0.007	0.004	1.755	0.499	2.125	6
-97.3218	30.2849	0.081	0.007	0.003	1.757	0.508	2.195	6
-97.3218	30.2849	0.081	0.007	0.004	1.757	0.505	2.22	6
-97.3218	30.2849	0.15	0.008	0.004	1.749	0.501	2.31	6
-97.3218	30.2849	0.069	0.008	0.004	1.748	0.504	2.361	6
-97.3218	30.2849	0.069	0.007	0.004	1.748	0.499	2.365	6
-97.3218	30.2849	0.035	0.008	0.004	1.756	0.505	2.366	6
-97.3218	30.2849	0.127	0.007	0.004	1.752	0.516	2.361	6
-97.3218	30.2849	0.173	0.008	0.004	1.745	0.498	2.356	6
-97.3218	30.2849	0.104	0.007	0.004	1.746	0.51	2.387	6
-97.3218	30.2849	0.069	0.007	0.004	1.754	0.501	2.376	6
-97.3218	30.2849	0.035	0.007	0.004	1.748	0.505	2.341	6
-97.3218	30.2849	0.092	0.007	0.004	1.75	0.509	2.355	6
-97.3218	30.2849	0.15	0.007	0.004	1.753	0.506	2.348	6
-97.3218	30.2849	0.069	0.007	0.004	1.739	0.501	2.29	6
-97.3218	30.2849	0.046	0.007	0.004	1.747	0.501	2.292	6
-97.3218	30.2849	0.092	0.007	0.004	1.747	0.498	2.279	6
-97.3218	30.2849	0.012	0.007	0.004	1.738	0.504	2.277	6
-97.3218	30.2849	0.081	0.007	0.004	1.743	0.507	2.279	6
-97.3218	30.2849	0.058	0.007	0.004	1.74	0.507	2.286	6
-97.3218	30.2849	0.069	0.007	0.004	1.739	0.5	2.285	6
-97.3218	30.2849	0.069	0.007	0.004	1.733	0.495	2.273	6
-97.3218	30.2849	0.069	0.008	0.004	1.748	0.504	2.241	6
-97.3218	30.2849	0.081	0.007	0.004	1.733	0.504	2.238	6
-97.3218	30.2849	0.023	0.008	0.004	1.735	0.505	2.236	6
-97.3218	30.2849	0.046	0.007	0.004	1.737	0.503	2.214	6
-97.3218	30.2849	0.207	0.007	0.004	1.737	0.503	2.208	6
-97.3218	30.2849	0.104	0.007	0.004	1.739	0.506	2.191	6
-97.3218	30.2849	0.058	0.007	0.004	1.743	0.501	2.188	6
-97.3218	30.2849	0.104	0.007	0.004	1.737	0.502	2.145	6
-97.3218	30.2849	0.081	0.007	0.004	1.736	0.502	1.998	6

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.081	0.007	0.004	1.736	0.501	2.172	6
-97.3218	30.2849	0.081	0.008	0.004	1.732	0.502	2.072	6
-97.3218	30.2849	0.023	0.007	0.004	0.51	0.501	1.316	6
-97.3218	30.2849	0.058	0.008	0.004	0.501	0.495	0.903	6
-97.3218	30.2849	0.104	0.008	0.004	0.499	0.5	0.841	6
-97.3218	30.2849	0.023	0.007	0.004	0.499	0.498	0.49	6
-97.3218	30.2849	0.104	0.007	0.004	0.496	0.497	0.49	6
-97.3218	30.2849	0.081	0.007	0.004	0.498	0.505	0.492	6
-97.3218	30.2849	0.069	0.007	0.004	0.5	0.497	0.491	6
-97.3218	30.2849	0.104	0.007	0.004	0.496	0.501	0.494	6
-97.3218	30.2849	0.058	0.007	0.004	0.494	0.508	0.497	6
-97.3218	30.2849	0.012	0.007	0.004	0.494	0.495	0.485	6
-97.3218	30.2849	0.058	0.007	0.004	0.492	0.501	0.481	6
-97.3218	30.2849	0.092	0.007	0.004	0.498	0.509	0.473	7
-97.3218	30.2849	0.046	0.007	0.004	0.504	0.5	0.476	7
-97.3218	30.2849	0.058	0.007	0.004	0.499	0.5	0.39	7
-97.3218	30.2849	0.023	0.007	0.004	0.496	0.503	0.692	7
-97.3218	30.2849	0.069	0.008	0.004	0.499	0.504	1.095	7
-97.3218	30.2849	0.081	0.008	0.004	0.503	0.503	2.156	7
-97.3218	30.2849	0.092	0.007	0.004	0.504	0.505	2.004	7
-97.3218	30.2849	0.046	0.007	0.004	0.495	0.505	1.936	7
-97.3218	30.2849	0.046	0.007	0.004	0.497	0.503	2.251	7
-97.3218	30.2849	0.058	0.007	0.004	0.5	0.511	2.187	7
-97.3218	30.2849	0.058	0.007	0.003	0.498	0.504	2.162	7
-97.3218	30.2849	0.023	0.007	0.004	0.494	0.503	2.184	7
-97.3218	30.2849	0.196	0.007	0.004	0.496	0.502	2.186	7
-97.3218	30.2849	0.058	0.007	0.004	0.496	0.503	2.166	7
-97.3218	30.2849	0.219	0.007	0.004	0.507	0.497	2.054	7
-97.3218	30.2849	0.196	0.007	0.004	0.499	0.5	2.125	7
-97.3218	30.2849	0.242	0.007	0.004	0.49	0.507	2.109	7
-97.3218	30.2849	0.092	0.007	0.004	0.499	0.506	2.14	7
-97.3218	30.2849	0.127	0.007	0.004	0.505	0.5	2.111	7
-97.3218	30.2849	0.104	0.007	0.004	0.581	0.503	2.107	7
-97.3218	30.2849	0.104	0.007	0.004	0.681	0.497	2.12	7
-97.3218	30.2849	0.023	0.007	0.004	0.782	0.497	2.113	7
-97.3218	30.2849	0.161	0.007	0.004	0.867	0.508	2.097	7
-97.3218	30.2849	0.046	0.007	0.004	0.875	0.507	2.155	7
-97.3218	30.2849	0.035	0.007	0.004	0.968	0.503	2.104	7
-97.3218	30.2849	0.115	0.007	0.004	1.08	0.508	2.125	7

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.081	0.007	0.004	1.155	0.501	2.074	7
-97.3218	30.2849	0.069	0.007	0.004	1.212	0.502	2.074	7
-97.3218	30.2849	0.046	0.007	0.004	1.235	0.5	2.07	7
-97.3218	30.2849	0.058	0.007	0.004	1.277	0.503	2.068	7
-97.3218	30.2849	0.023	0.007	0.004	1.319	0.502	2.073	7
-97.3218	30.2849	0.104	0.007	0.004	1.404	0.507	2.065	7
-97.3218	30.2849	0.046	0.007	0.004	1.451	0.504	2.061	7
-97.3218	30.2849	0.069	0.007	0.004	1.487	0.5	2.058	7
-97.3218	30.2849	0.081	0.007	0.004	1.494	0.505	2.124	7
-97.3218	30.2849	0.092	0.007	0.003	1.491	0.505	2.148	7
-97.3218	30.2849	0.081	0.007	0.004	1.501	0.5	2.073	7
-97.3218	30.2849	0.069	0.007	0.003	1.618	0.5	2.07	7
-97.3218	30.2849	0.15	0.007	0.004	1.667	0.502	2.08	7
-97.3218	30.2849	0.058	0.007	0.004	1.719	0.51	2.056	7
-97.3218	30.2849	0.23	0.007	0.004	1.743	0.511	2.067	7
-97.3218	30.2849	0.242	0.007	0.004	1.781	0.504	2.062	7
-97.3218	30.2849	0.035	0.007	0.004	1.834	0.499	2.056	7
-97.3218	30.2849	0.104	0.007	0.004	1.854	0.507	2.058	7
-97.3218	30.2849	0.069	0.007	0.004	1.891	0.507	2.051	7
-97.3218	30.2849	0.127	0.007	0.004	1.909	0.513	2.05	7
-97.3218	30.2849	0.081	0.007	0.004	1.944	0.506	2.046	7
-97.3218	30.2849	0.058	0.008	0.004	1.951	0.506	2.064	7
-97.3218	30.2849	0.081	0.007	0.004	1.948	0.512	2.137	7
-97.3218	30.2849	0.127	0.007	0.004	1.958	0.502	2.131	7
-97.3218	30.2849	0.023	0.007	0.004	2.074	0.497	2.059	7
-97.3218	30.2849	0.115	0.007	0.004	2.157	0.503	2.072	7
-97.3218	30.2849	0.127	0.008	0.004	2.256	0.503	2.069	7
-97.3218	30.2849	0.104	0.008	0.004	2.339	0.505	2.068	7
-97.3218	30.2849	0.207	0.008	0.004	2.392	0.504	2.059	7
-97.3218	30.2849	0.058	0.008	0.004	2.495	0.504	2.056	7
-97.3218	30.2849	0.035	0.008	0.004	2.561	0.512	2.052	7
-97.3218	30.2849	0.012	0.007	0.004	2.549	0.506	2.095	7
-97.3218	30.2849	0.046	0.007	0.004	2.557	0.509	2.242	7
-97.3218	30.2849	0.023	0.007	0.004	2.557	0.508	2.269	7
-97.3218	30.2849	0.196	0.007	0.004	2.555	0.501	2.165	7
-97.3218	30.2849	0.161	0.007	0.004	2.559	0.503	2.229	7
-97.3218	30.2849	0.046	0.007	0.004	2.546	0.501	2.281	7
-97.3218	30.2849	0.15	0.008	0.005	2.549	0.506	2.253	7
-97.3218	30.2849	0.115	0.007	0.004	2.558	0.499	2.264	7

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.081	0.007	0.004	2.543	0.5	2.281	7
-97.3218	30.2849	0.058	0.007	0.004	2.552	0.507	2.22	7
-97.3218	30.2849	0.046	0.007	0.004	2.545	0.503	2.229	7
-97.3218	30.2849	0.092	0.007	0.004	2.544	0.499	2.187	7
-97.3218	30.2849	0.058	0.007	0.004	2.541	0.507	2.219	7
-97.3218	30.2849	0.173	0.007	0.004	2.551	0.508	2.222	7
-97.3218	30.2849	0.046	0.007	0.004	2.54	0.503	2.203	7
-97.3218	30.2849	0.081	0.007	0.004	2.543	0.507	2.212	7
-97.3218	30.2849	0.081	0.007	0.004	2.534	0.504	2.21	7
-97.3218	30.2849	0.058	0.007	0.004	2.547	0.507	2.219	7
-97.3218	30.2849	0.138	0.007	0.004	2.538	0.505	2.208	7
-97.3218	30.2849	0.092	0.007	0.004	2.543	0.506	2.204	7
-97.3218	30.2849	0.092	0.007	0.004	2.545	0.507	2.202	7
-97.3218	30.2849	0.046	0.007	0.004	2.537	0.508	2.178	7
-97.3218	30.2849	0.058	0.008	0.004	2.542	0.507	2.168	7
-97.3218	30.2849	0.092	0.007	0.004	2.538	0.509	2.215	7
-97.3218	30.2849	0.081	0.007	0.004	2.545	0.508	2.228	7
-97.3218	30.2849	0.115	0.007	0.004	2.537	0.504	2.154	7
-97.3218	30.2849	0.104	0.007	0.004	2.534	0.503	1.683	7
-97.3218	30.2849	0.035	0.007	0.004	0.512	0.502	0.215	7
-97.3218	30.2849	0.035	0.007	0.004	0.498	0.505	0.319	7
-97.3218	30.2849	0.046	0.007	0.004	0.5	0.5	0.284	7
-97.3218	30.2849	0.069	0.008	0.004	0.496	0.51	0.368	7
-97.3218	30.2849	0.104	0.007	0.004	0.495	0.504	0.36	7
-97.3218	30.2849	0.081	0.007	0.004	0.497	0.499	0.486	7
-97.3218	30.2849	0.104	0.007	0.004	0.501	0.509	0.437	7
-97.3218	30.2849	0.092	0.007	0.004	0.5	0.504	0.413	7
-97.3218	30.2849	0.127	0.007	0.004	0.493	0.501	0.42	7
-97.3218	30.2849	0.138	0.007	0.004	0.5	0.505	0.422	7
-97.3218	30.2849	0.104	0.007	0.004	0.501	0.498	0.421	8
-97.3218	30.2849	0.069	0.007	0.004	0.493	0.497	0.488	8
-97.3218	30.2849	0.081	0.007	0.004	0.504	0.497	0.578	8
-97.3218	30.2849	0.058	0.007	0.004	0.493	0.5	0.696	8
-97.3218	30.2849	0.035	0.007	0.004	0.501	0.503	0.665	8
-97.3218	30.2849	0.161	0.007	0.004	0.496	0.501	1.069	8
-97.3218	30.2849	0.023	0.007	0.004	0.496	0.498	1.569	8
-97.3218	30.2849	0.069	0.007	0.004	0.505	0.509	1.755	8
-97.3218	30.2849	0.173	0.007	0.004	0.627	0.504	1.761	8
-97.3218	30.2849	0.023	0.007	0.004	0.944	0.504	1.743	8

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.173	0.007	0.004	1.189	0.501	1.742	8
-97.3218	30.2849	0.092	0.007	0.004	1.298	0.502	1.758	8
-97.3218	30.2849	0.046	0.007	0.004	1.302	0.503	1.966	8
-97.3218	30.2849	0.081	0.008	0.004	1.296	0.505	1.826	8
-97.3218	30.2849	0.161	0.008	0.003	1.288	0.509	1.927	8
-97.3218	30.2849	0.092	0.007	0.004	1.289	0.497	1.991	8
-97.3218	30.2849	0.035	0.008	0.004	1.289	0.504	2.019	8
-97.3218	30.2849	0.058	0.007	0.004	1.292	0.497	2.014	8
-97.3218	30.2849	0.242	0.008	0.004	1.292	0.507	2.024	8
-97.3218	30.2849	0.046	0.008	0.004	1.285	0.503	2.014	8
-97.3218	30.2849	0.092	0.008	0.004	1.289	0.501	2.006	8
-97.3218	30.2849	0.069	0.007	0.004	1.285	0.498	2.007	8
-97.3218	30.2849	0.035	0.008	0.004	1.287	0.507	2.009	8
-97.3218	30.2849	0.23	0.007	0.004	1.296	0.502	2.13	8
-97.3218	30.2849	0.127	0.007	0.004	1.289	0.499	2.207	8
-97.3218	30.2849	0.035	0.007	0.004	1.274	0.501	2.096	8
-97.3218	30.2849	0.058	0.008	0.004	1.287	0.498	2.078	8
-97.3218	30.2849	0.173	0.007	0.004	1.293	0.507	2.086	8
-97.3218	30.2849	0.046	0.008	0.004	1.286	0.509	2.085	8
-97.3218	30.2849	0.104	0.007	0.004	1.282	0.494	2.085	8
-97.3218	30.2849	0.046	0.007	0.003	1.287	0.502	2.076	8
-97.3218	30.2849	0.012	0.007	0.004	1.284	0.504	2.083	8
-97.3218	30.2849	0.081	0.007	0.004	1.28	0.502	2.084	8
-97.3218	30.2849	0.173	0.007	0.004	1.278	0.505	2.074	8
-97.3218	30.2849	0.092	0.008	0.004	1.281	0.503	2.064	8
-97.3218	30.2849	0.104	0.007	0.004	1.283	0.5	2.1	8
-97.3218	30.2849	0.138	0.008	0.005	1.28	0.506	2.116	8
-97.3218	30.2849	0.069	0.008	0.004	1.284	0.5	2.173	8
-97.3218	30.2849	0.104	0.008	0.004	1.282	0.507	2.139	8
-97.3218	30.2849	0.115	0.008	0.004	1.277	0.507	2.119	8
-97.3218	30.2849	0.15	0.008	0.005	1.278	0.503	2.134	8
-97.3218	30.2849	0.035	0.008	0.004	1.281	0.505	2.107	8
-97.3218	30.2849	0.081	0.008	0.004	1.276	0.5	2.111	8
-97.3218	30.2849	0.058	0.008	0.004	1.28	0.506	2.091	8
-97.3218	30.2849	0.196	0.007	0.004	1.282	0.497	2.072	8
-97.3218	30.2849	0.184	0.007	0.004	1.28	0.511	2.092	8
-97.3218	30.2849	0.069	0.007	0.004	1.273	0.505	2.074	8
-97.3218	30.2849	0.127	0.007	0.004	1.281	0.501	2.041	8
-97.3218	30.2849	0.058	0.007	0.004	1.269	0.504	1.952	8

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.15	0.008	0.004	1.275	0.504	1.935	8
-97.3218	30.2849	0.046	0.008	0.004	1.269	0.504	1.192	8
-97.3218	30.2849	0.058	0.007	0.005	0.502	0.5	0.243	8
-97.3218	30.2849	0.035	0.007	0.004	0.503	0.51	0.324	8
-97.3218	30.2849	0.081	0.007	0.004	0.513	0.516	0.354	8
-97.3218	30.2849	0.069	0.008	0.004	0.499	0.505	0.344	8
-97.3218	30.2849	0.023	0.008	0.004	0.498	0.509	0.38	8
-97.3218	30.2849	0.023	0.007	0.004	0.494	0.501	0.371	8
-97.3218	30.2849	0.104	0.007	0.004	0.495	0.502	0.371	8
-97.3218	30.2849	0.069	0.008	0.004	0.494	0.502	0.393	8
-97.3218	30.2849	0.15	0.007	0.004	0.493	0.501	0.452	8
-97.3218	30.2849	0.196	0.007	0.004	0.504	0.503	0.667	9
-97.3218	30.2849	0.035	0.007	0.004	0.5	0.504	2.037	9
-97.3218	30.2849	0.081	0.007	0.004	0.501	0.505	2.485	9
-97.3218	30.2849	0.081	0.007	0.004	0.498	0.504	2.32	9
-97.3218	30.2849	0.069	0.007	0.004	0.501	0.503	2.352	9
-97.3218	30.2849	0.035	0.007	0.004	0.499	0.504	2.217	9
-97.3218	30.2849	0.023	0.007	0.004	0.499	0.507	1.705	9
-97.3218	30.2849	0.092	0.007	0.004	0.507	0.507	1.749	9
-97.3218	30.2849	0.115	0.007	0.004	0.5	0.5	1.837	9
-97.3218	30.2849	0.127	0.007	0.004	0.501	0.505	1.815	9
-97.3218	30.2849	0.253	0.007	0.004	0.498	0.497	1.879	9
-97.3218	30.2849	0.127	0.007	0.004	0.499	0.501	1.839	9
-97.3218	30.2849	0.058	0.007	0.004	0.498	0.494	1.742	9
-97.3218	30.2849	0.058	0.007	0.005	0.497	0.5	1.733	9
-97.3218	30.2849	0.104	0.007	0.005	0.498	0.509	1.595	9
-97.3218	30.2849	0.092	0.007	0.004	0.494	0.506	1.511	9
-97.3218	30.2849	0.23	0.008	0.004	0.504	0.498	1.533	9
-97.3218	30.2849	0.161	0.007	0.004	0.495	0.498	1.624	9
-97.3218	30.2849	0.046	0.007	0.004	0.497	0.508	1.622	9
-97.3218	30.2849	0.081	0.007	0.005	0.499	0.502	1.635	9
-97.3218	30.2849	0.035	0.007	0.004	0.503	0.504	1.642	9
-97.3218	30.2849	0.023	0.007	0.005	0.499	0.496	1.63	9
-97.3218	30.2849	0.058	0.008	0.004	0.495	0.502	1.74	9
-97.3218	30.2849	0.035	0.007	0.005	0.503	0.505	1.793	9
-97.3218	30.2849	0.092	0.007	0.005	0.502	0.501	1.766	9
-97.3218	30.2849	0.081	0.007	0.005	0.496	0.5	1.788	9
-97.3218	30.2849	0.023	0.007	0.004	0.5	0.502	1.772	9
-97.3218	30.2849	0.207	0.007	0.005	0.496	0.5	1.766	9

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.092	0.007	0.004	0.494	0.495	1.776	9
-97.3218	30.2849	0.046	0.007	0.004	0.501	0.501	1.76	9
-97.3218	30.2849	0.046	0.007	0.004	0.498	0.505	1.794	9
-97.3218	30.2849	0.161	0.007	0.004	0.501	0.502	1.716	9
-97.3218	30.2849	0.058	0.007	0.004	0.492	0.495	1.718	9
-97.3218	30.2849	0.207	0.007	0.004	0.499	0.504	1.728	9
-97.3218	30.2849	0.023	0.007	0.004	0.5	0.5	1.728	9
-97.3218	30.2849	0.115	0.007	0.004	0.5	0.502	1.692	9
-97.3218	30.2849	0.069	0.007	0.004	0.5	0.499	1.508	9
-97.3218	30.2849	0.035	0.007	0.004	0.505	0.503	1.572	9
-97.3218	30.2849	0.161	0.007	0.004	0.494	0.503	1.569	9
-97.3218	30.2849	0.242	0.007	0.004	0.502	0.51	1.568	9
-97.3218	30.2849	0.115	0.007	0.004	0.499	0.503	1.513	9
-97.3218	30.2849	0.115	0.007	0.004	0.498	0.504	1.516	9
-97.3218	30.2849	0.104	0.007	0.004	0.495	0.504	1.525	9
-97.3218	30.2849	0.046	0.007	0.004	0.499	0.502	1.516	9
-97.3218	30.2849	0.012	0.007	0.004	0.498	0.508	1.456	9
-97.3218	30.2849	0.081	0.007	0.005	0.506	0.497	1.305	9
-97.3218	30.2849	0.081	0.007	0.005	0.504	0.505	1.302	9
-97.3218	30.2849	0.058	0.007	0.004	0.512	0.504	1.297	9
-97.3218	30.2849	0.196	0.007	0.004	0.557	0.502	1.288	9
-97.3218	30.2849	0.081	0.007	0.004	0.612	0.502	1.292	9
-97.3218	30.2849	0.161	0.007	0.004	0.64	0.507	1.297	9
-97.3218	30.2849	0.069	0.007	0.004	0.668	0.506	1.295	9
-97.3218	30.2849	0.046	0.008	0.004	0.719	0.507	1.293	9
-97.3218	30.2849	0.046	0.007	0.004	0.765	0.508	1.29	9
-97.3218	30.2849	0.092	0.007	0.004	0.779	0.497	1.293	9
-97.3218	30.2849	0.058	0.007	0.004	0.8	0.5	1.29	9
-97.3218	30.2849	0.046	0.007	0.004	0.797	0.503	1.307	9
-97.3218	30.2849	0.173	0.007	0.004	0.79	0.5	1.29	9
-97.3218	30.2849	0.15	0.007	0.004	0.881	0.502	1.253	9
-97.3218	30.2849	0.058	0.007	0.004	0.932	0.495	1.248	9
-97.3218	30.2849	0.046	0.007	0.004	0.954	0.499	1.249	9
-97.3218	30.2849	0.023	0.007	0.004	0.971	0.502	1.248	9
-97.3218	30.2849	0.184	0.007	0.004	0.975	0.505	1.337	9
-97.3218	30.2849	0.253	0.007	0.004	0.973	0.501	1.164	9
-97.3218	30.2849	0.058	0.007	0.004	0.968	0.509	1.16	9
-97.3218	30.2849	0.035	0.007	0.004	0.971	0.497	1.151	9
-97.3218	30.2849	0.058	0.007	0.004	0.969	0.5	1.155	9

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.207	0.007	0.004	1.03	0.505	1.144	9
-97.3218	30.2849	0.058	0.007	0.004	1.071	0.496	1.128	9
-97.3218	30.2849	0.081	0.007	0.004	1.203	0.507	1.135	9
-97.3218	30.2849	0.081	0.007	0.004	1.24	0.508	1.113	9
-97.3218	30.2849	0.138	0.007	0.004	1.278	0.501	1.114	9
-97.3218	30.2849	0.035	0.007	0.004	1.325	0.506	1.104	9
-97.3218	30.2849	0.104	0.007	0.004	1.441	0.506	1.11	10
-97.3218	30.2849	0.046	0.008	0.004	1.496	0.506	1.102	10
-97.3218	30.2849	0.058	0.007	0.004	1.53	0.504	1.103	10
-97.3218	30.2849	0.104	0.007	0.004	1.584	0.509	1.111	10
-97.3218	30.2849	0.058	0.007	0.004	1.656	0.503	1.108	10
-97.3218	30.2849	0.058	0.007	0.004	1.71	0.504	1.105	10
-97.3218	30.2849	0.173	0.007	0.004	1.73	0.503	1.116	10
-97.3218	30.2849	0.138	0.008	0.004	1.783	0.502	1.111	10
-97.3218	30.2849	0.035	0.008	0.004	1.821	0.505	1.12	10
-97.3218	30.2849	0.046	0.007	0.004	1.862	0.507	1.121	10
-97.3218	30.2849	0.081	0.007	0.004	1.898	0.505	1.119	10
-97.3218	30.2849	0.115	0.007	0.004	1.929	0.502	1.111	10
-97.3218	30.2849	0.046	0.007	0.003	1.981	0.506	1.118	10
-97.3218	30.2849	0.104	0.007	0.004	2.031	0.493	1.108	10
-97.3218	30.2849	0.127	0.008	0.004	2.033	0.501	1.119	10
-97.3218	30.2849	0.058	0.008	0.004	2.025	0.507	1.241	10
-97.3218	30.2849	0.035	0.008	0.004	2.029	0.504	1.306	10
-97.3218	30.2849	0.092	0.007	0.004	2.03	0.506	1.291	10
-97.3218	30.2849	0.035	0.008	0.004	2.03	0.493	1.189	10
-97.3218	30.2849	0.115	0.007	0.004	2.207	0.502	1.197	10
-97.3218	30.2849	0.012	0.008	0.004	2.282	0.503	1.198	10
-97.3218	30.2849	0.012	0.008	0.004	2.358	0.501	1.191	10
-97.3218	30.2849	0.127	0.008	0.004	2.444	0.509	1.195	10
-97.3218	30.2849	0.012	0.008	0.004	2.502	0.505	1.259	10
-97.3218	30.2849	0.127	0.008	0.004	2.503	0.503	2.397	10
-97.3218	30.2849	0.058	0.007	0.004	2.495	0.505	2.351	10
-97.3218	30.2849	0.023	0.008	0.004	2.491	0.5	2.568	10
-97.3218	30.2849	0.023	0.007	0.004	2.494	0.503	2.24	10
-97.3218	30.2849	0.023	0.008	0.004	2.49	0.505	2.252	10
-97.3218	30.2849	0.046	0.007	0.004	2.496	0.505	2.248	10
-97.3218	30.2849	0.092	0.007	0.004	2.488	0.51	2.239	10
-97.3218	30.2849	0.081	0.007	0.004	2.484	0.504	2.234	10
-97.3218	30.2849	0.046	0.007	0.004	2.493	0.511	2.228	10

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.115	0.007	0.004	2.496	0.504	2.23	10
-97.3218	30.2849	0.081	0.007	0.004	2.489	0.508	2.226	10
-97.3218	30.2849	0.035	0.008	0.004	2.491	0.502	2.227	10
-97.3218	30.2849	0.035	0.008	0.004	2.485	0.506	2.224	10
-97.3218	30.2849	0.069	0.008	0.004	2.487	0.505	2.22	10
-97.3218	30.2849	0.046	0.007	0.004	2.484	0.503	2.25	10
-97.3218	30.2849	0.046	0.007	0.004	2.495	0.499	2.736	10
-97.3218	30.2849	0.035	0.007	0.004	2.482	0.507	2.549	10
-97.3218	30.2849	0.058	0.007	0.004	2.48	0.495	2.441	10
-97.3218	30.2849	0.035	0.007	0.004	2.487	0.498	2.457	10
-97.3218	30.2849	0.069	0.007	0.004	2.484	0.503	2.386	10
-97.3218	30.2849	0.15	0.007	0.004	2.485	0.504	2.395	10
-97.3218	30.2849	0.035	0.007	0.004	2.481	0.499	2.372	10
-97.3218	30.2849	0.012	0.007	0.004	2.484	0.503	2.893	10
-97.3218	30.2849	0.046	0.007	0.004	2.475	0.501	2.655	10
-97.3218	30.2849	0.081	0.007	0.004	2.475	0.508	2.741	10
-97.3218	30.2849	0.023	0.007	0.004	2.469	0.502	2.738	10
-97.3218	30.2849	0.081	0.007	0.004	2.483	0.503	2.743	10
-97.3218	30.2849	0.046	0.007	0.004	2.482	0.502	2.742	10
-97.3218	30.2849	0.092	0.007	0.004	2.484	0.503	2.741	10
-97.3218	30.2849	0.092	0.007	0.004	2.477	0.505	2.744	10
-97.3218	30.2849	0.081	0.007	0.004	2.471	0.506	2.763	10
-97.3218	30.2849	0.058	0.007	0.004	2.469	0.499	2.768	10
-97.3218	30.2849	0.046	0.007	0.004	2.482	0.502	2.772	10
-97.3218	30.2849	0.046	0.007	0.004	2.482	0.505	2.766	10
-97.3218	30.2849	0.092	0.007	0.004	2.473	0.509	2.781	10
-97.3218	30.2849	0.035	0.007	0.004	2.474	0.503	2.775	10
-97.3218	30.2849	0.035	0.007	0.004	2.479	0.509	2.778	10
-97.3218	30.2849	0.104	0.007	0.004	2.465	0.504	2.771	10
-97.3218	30.2849	0.069	0.007	0.004	2.467	0.503	2.785	10
-97.3218	30.2849	0.046	0.007	0.004	2.476	0.505	2.872	10
-97.3218	30.2849	0.069	0.007	0.004	2.479	0.507	2.835	10
-97.3218	30.2849	0.058	0.007	0.004	2.465	0.51	2.716	10
-97.3218	30.2849	0.035	0.008	0.004	2.467	0.504	2.791	10
-97.3218	30.2849	0.046	0.007	0.004	2.466	0.504	2.709	10
-97.3218	30.2849	0.046	0.007	0.004	2.464	0.508	2.743	10
-97.3218	30.2849	0.104	0.007	0.004	2.467	0.503	2.746	10
-97.3218	30.2849	0.069	0.007	0.004	2.477	0.502	2.73	10
-97.3218	30.2849	0.138	0.007	0.004	2.473	0.506	2.567	10

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.104	0.007	0.004	2.47	0.511	2.437	10
-97.3218	30.2849	0.035	0.007	0.004	2.463	0.507	1.506	10
-97.3218	30.2849	0.081	0.007	0.004	0.512	0.506	0.419	10
-97.3218	30.2849	0.058	0.007	0.004	0.502	0.51	0.963	10
-97.3218	30.2849	0.035	0.007	0.004	0.496	0.507	0.95	10
-97.3218	30.2849	0.058	0.007	0.004	0.5	0.503	1.144	10
-97.3218	30.2849	0.092	0.007	0.004	0.503	0.512	1.256	10
-97.3218	30.2849	0.127	0.007	0.004	0.511	0.509	1.303	10
-97.3218	30.2849	0.035	0.007	0.004	0.496	0.508	1.3	10
-97.3218	30.2849	0.035	0.007	0.004	0.502	0.504	1.314	10
-97.3218	30.2849	0.104	0.007	0.004	0.5	0.506	1.324	10
-97.3218	30.2849	0.058	0.007	0.004	0.498	0.501	1.321	10
-97.3218	30.2849	0.035	0.007	0.004	0.495	0.507	1.325	10
-97.3218	30.2849	0.023	0.007	0.004	0.501	0.504	1.277	10
-97.3218	30.2849	0.035	0.008	0.004	0.5	0.502	0.197	10
-97.3218	30.2849	0.092	0.007	0.004	0.5	0.505	0.006	10
-97.3218	30.2849	0.035	0.008	0.004	0.5	0.502	0.013	10
-97.3218	30.2849	0.058	0.008	0.004	0.494	0.502	0.01	10
-97.3218	30.2849	0.035	0.008	0.004	0.497	0.514	0.014	10
-97.3218	30.2849	0.058	0.007	0.004	0.492	0.492	0.009	10
-97.3218	30.2849	0.115	0.007	0.004	0.504	0.504	0.014	10
-97.3218	30.2849	0.092	0.007	0.004	0.5	0.506	0.035	10
-97.3218	30.2849	0.081	0.008	0.004	0.502	0.499	0.089	10
-97.3218	30.2849	0.104	0.007	0.004	0.501	0.508	0.1	10
-97.3218	30.2849	0.023	0.007	0.004	0.494	0.499	0.119	11
-97.3218	30.2849	0.058	0.007	0.004	0.502	0.51	0.118	11
-97.3218	30.2849	0.184	0.007	0.004	0.501	0.508	0.108	11
-97.3218	30.2849	0.046	0.007	0.004	0.496	0.499	0.178	11
-97.3218	30.2849	0.081	0.007	0.004	0.494	0.503	0.169	11
-97.3218	30.2849	0.115	0.007	0.004	0.502	0.497	0.343	11
-97.3218	30.2849	0.035	0.007	0.004	0.495	0.51	0.489	11
-97.3218	30.2849	0.046	0.007	0.004	0.499	0.504	0.576	11
-97.3218	30.2849	0.023	0.007	0.004	0.5	0.506	1.093	11
-97.3218	30.2849	0.035	0.007	0.004	0.497	0.506	2.393	11
-97.3218	30.2849	0.081	0.007	0.005	0.686	0.503	2.216	11
-97.3218	30.2849	0.069	0.006	0.004	1.833	0.498	2.139	11
-97.3218	30.2849	0.138	0.007	0.004	1.961	0.502	2.096	11
-97.3218	30.2849	0.081	0.007	0.004	1.961	0.5	2.137	11
-97.3218	30.2849	0.058	0.007	0.004	1.959	0.498	2.185	11

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.2849	0.069	0.007	0.004	1.957	0.507	2.198	11
-97.3218	30.2849	0.046	0.007	0.004	1.952	0.503	2.284	11
-97.3218	30.2849	0.023	0.007	0.004	1.951	0.503	2.313	11
-97.3218	30.2849	0.023	0.007	0.004	1.943	0.51	2.317	11
-97.3218	30.2849	0.058	0.007	0.004	1.953	0.504	2.134	11
-97.3218	30.2849	0.081	0.008	0.004	1.935	0.502	2.205	11
-97.3218	30.2849	0.081	0.007	0.004	1.948	0.502	2.293	11
-97.3218	30.2849	0.069	0.007	0.004	1.95	0.506	2.313	11
-97.3218	30.2849	0.046	0.007	0.004	1.945	0.508	2.281	11
-97.3218	30.2849	0.069	0.007	0.004	1.933	0.502	2.265	11
-97.3218	30.2849	0.046	0.007	0.004	1.934	0.5	2.285	11
-97.3218	30.2849	0.058	0.007	0.003	1.942	0.504	2.258	11
-97.3218	30.2849	0.115	0.007	0.004	1.947	0.506	2.275	11
-97.3218	30.2849	0.035	0.007	0.004	1.94	0.502	2.276	11
-97.3218	30.2849	0.023	0.007	0.003	1.942	0.506	2.263	11
-97.3218	30.2849	0.035	0.007	0.003	1.942	0.501	2.271	11
-97.3218	30.2849	0.069	0.007	0.004	1.942	0.502	2.254	11
-97.3218	30.2849	0.058	0.007	0.004	1.944	0.501	2.248	11
-97.3218	30.2849	0.046	0.007	0.004	1.931	0.5	2.201	11
-97.3218	30.2849	0.15	0.008	0.004	1.933	0.5	2.245	11
-97.3218	30.2849	0.15	0.007	0.004	1.927	0.505	2.244	11
-97.3218	30.2849	0.046	0.007	0.004	1.937	0.503	2.182	11
-97.3218	30.2849	0.046	0.007	0.004	1.937	0.506	2.191	11
-97.3218	30.2849	0.058	0.008	0.004	1.933	0.514	2.161	11
-97.3218	30.2849	0.023	0.007	0.004	1.933	0.505	2.156	11
-97.3218	30.2849	0.092	0.007	0.004	1.936	0.507	2.147	11
-97.3218	30.2849	0.035	0.007	0.004	1.934	0.499	2.043	11
-97.3218	30.2849	0.069	0.008	0.004	1.928	0.505	2.03	11
-97.3218	30.2849	0.127	0.007	0.004	1.935	0.501	2.099	11
-97.3218	30.2849	0.104	0.007	0.004	1.931	0.503	2.206	11
-97.3218	30.2849	0.058	0.007	0.005	1.93	0.507	2.259	11
-97.3218	30.28491	0.069	0.007	0.005	1.928	0.504	2.187	11
-97.3218	30.28491	0.081	0.007	0.004	1.931	0.504	2.163	11
-97.3218	30.28491	0.058	0.008	0.004	1.932	0.502	2.148	11
-97.3218	30.28491	0.046	0.007	0.004	1.932	0.506	2.144	11
-97.3218	30.28491	0.035	0.008	0.004	1.927	0.508	2.172	11
-97.3218	30.28491	0.023	0.007	0.004	1.934	0.502	2.218	11
-97.3218	30.28491	0.058	0.007	0.004	1.93	0.505	2.299	11
-97.3218	30.28491	0.023	0.007	0.004	1.924	0.499	1.305	11

Longitude	Latitude	Speed	YldS1	YldS2	LC1	LC2	Incl	Basket
-97.3218	30.28491	0.023	0.007	0.004	1.932	0.498	0.618	11
-97.3218	30.28491	0.046	0.007	0.004	1.927	0.5	0.41	11
-97.3218	30.28491	0.046	0.007	0.004	1.247	0.508	0.534	11
-97.3218	30.28491	0.069	0.007	0.004	0.5	0.506	0.544	11
-97.3218	30.28491	0.058	0.007	0.004	0.495	0.502	0.614	11

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