NEW TECHNOLOGIES FOR MANAGING COTTON MODULES AND HARVEST INFORMATION

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Abstract

Radio frequency identification (RFID) tags incorporated into the plastic wrap used to cover round modules formed by John Deere cotton harvesters provide the foundation of a new system for identifying cotton modules and transferring harvest related data to downstream users. Each RFID tag contains a module identifier (module ID) that is unique to that module. Harvesters equipped with the HID Cotton Pro system from John Deere create a database of harvest related data for each module using the module identifier as the primary key. The module ID can be read from the RFID tag using electronic scanning tools and used to help growers and ginners manage modules and associated information gathered during the harvesting, storage, transportation, and ginning processes. However, to date, no commercial systems have been developed to facilitate the collection of module ID or harvest related information using RFID technology. Therefore, the objective of this work was to develop 1) a scanning system for use on module trucks that automates the process of scanning modules and logging position and cotton ownership information into one location for use by producers and ginners. Development of these two systems in addition to a previously developed mobile application for scanning modules in the field (RFID Module Scan) and a program for automating the HID file download process (Cotton Harvest File Download Utility) provide the basis of a new system for electronic management of cotton modules using RFID technology.

Introduction

New cotton harvesters recently released by John Deere (CS 690 and CP 690) form round cotton modules onboard as the machines harvest cotton in the field. The round modules are wrapped in three-layers of engineered plastic film which restrain the cotton in cylindrical form and protect it from wind and moisture damage prior to ginning. The round modules offer other unique benefits relative to conventional cotton modules in regard to the extended maximum storage period prior to ginning and the ability to haul cotton on semi-tractor-trailer vehicles which cheapens the cost of transporting modules over long distances.

Each portion of plastic module wrap contains four passive RFID transponders (tags) and two human readable identification tags that display a serial number unique to each round module. The human readable tags also contain a 2D data matrix which can be scanned by a barcode reader. When interrogated, the RFID transponders and 2D data matrix return a 24 digit Module Identification number (Module ID) that contains the module serial number along with other information related to the manufacture of the wrap. Harvest ID – Cotton is a system offered by John Deere which associates the module ID number with other harvest related data (table 1) collected on the harvester. This data can be downloaded directly from the display in the harvester or transferred wirelessly from the harvester to the MyJohnDeere.com website where it is available to producers and anyone they wish to grant access. Part of the Harvest ID-Cotton system is an RFID reader on the harvester that scans the modules as the wrap is applied to the module. Other system components associate the module ID with other harvest data collected on the machine.

Module ID	Client	Gin ID
Module Serial Number	Farm	Producer ID
Latitude (wrap applied)	Field	Local Time
Longitude (wrap applied)	Variety	Field Area
GMT Date/Time	Machine PIN	Season Total Modules
Tag Count	Operator	Diameter
Module Weight*	Moisture Content*	Latitude (drop location)*
Longitude (drop location)*	Field Total Module Count*	Incremental Area*
Local Time/Date*	Comments*	

Table 1. Data available for each round module serial number on MyJohnDeere.com.

*Available in John Deere - HID Cotton-Pro released in 2017.

The use of RFID technology to identify cotton modules has enabled new methods for tracking and managing seed cotton from the field to the gin. This new technology creates new possibilities for logistical management, asset tracking, product traceability, and precision agriculture regarding fiber quality mapping. While some in the cotton ginning industry have used pieces of the system to create module inventory lists or pickup reports, no system exists that compiles all of the module ID and harvest data along with other additional RFID tag scan location data into one management system. The overall goal of this research is to develop an electronic module management system for use by gins which utilizes RFID technology and other associated systems to provide useful information (e.g. current module location, processing status, and load weight) to ginners and producers. The specific objectives of the work described in this manuscript are to develop 1) a scanning system for use on module trucks that automates the process of scanning modules and logging position and cotton ownership information as modules are loaded or unloaded, and 2) a data management utility that compiles module specific information into one location for use by producers and ginners. The systems described herein are components of the electronic module management system. Our goal is for this electronic module management system to be used to demonstrate the utility of this new module tracking technology and help producers and ginners identify new sources of value through the enhanced use of module location and harvest information.

Electronic Module Management System - "The Big Picture"

Since 2016, work has been underway at the USDA ARS Cotton Production and Processing Research Unit in Lubbock, TX to develop software and hardware tools needed to utilize RFID technology now incorporated in round module wrap in a system for tracking and managing cotton module location and harvest related data. The conceptual design of this Electronic Module Management System is shown in figure 1 with a schematic diagram of the dataflow shown in figure 2. In addition to the harvest data collected on the harvester, this system can be utilized to collect and manage module location information for modules from the time they are dropped by the harvester to the time they are placed on the module feeder for ginning. Harvest information collected for each module by the HID Cotton system on the harvester is transmitted to the MyJohnDeere.com website where an application named "Cotton Harvest File Download Utility" developed by Cotton Incorporated (2017) can be used to download the HID files to a PC running in the gin office. The HID file for a particular client, farm, and field contains all Module IDs and associated harvest data (table 1) collected on the harvester for each module - providing an inventory list of modules available for that field. Once downloaded, the information included in the HID files is added to the main database in the Data Management Utility (DMU). A mobile scanning tool named RFID Module Scan (Wanjura et. al., 2017) can be used to scan modules in the field after the staging operation or as they are dropped in the field to create the initial module inventory list in cases where the HID Cotton system is not available. RFID Module Scan was developed to run on Android devices and is available free of charge by searching for "RFID Module Scan" on the Google Play Store (Bohn Technology Solutions, 2017). RFID Module Scan can also be used to generate module storage yard inventory maps or provide a scanning tool for any scenario in which modules need to be identified and their location documented. A scanning system used on module trucks (Truck System) automates the process of scanning modules as they are loaded or unloaded and associates the GPS position of the loading/unloading process. The truck system software documents if the modules were loaded or unloaded during each scan and categorizes the scanning location for each module (e.g. "in field," "gin yard," "module feeder," etc.) All of the HID data and scan information from the RFID Module Scan app and Module Truck system are compiled in the Data Management Utility for use in generating reports useful to the gin staff or producers. With additional development, our goal is that the information contained in the Data Management Utility can be provided to producers and consultants for use in better managing cotton crops on a site specific basis with regard to fiber quality in addition to yield. Moreover, the information contained in the DMU may enhance the value of lint produced by providing information to merchants, mills, and garment manufacturers/retailers related to the specific location and production practices used to grow the cotton contained in a particular garment.

A ginner education session focused on new technologies for managing cotton modules was presented at the 2017 National Cotton Ginners Association Gin Schools. The presentations given during the school in Stoneville, MS were recorded and are available on the Plant Management Network Website (PMN, 2017).



Figure 1. Schematic overview of the components and dataflow within the Electronic Module Management System.



Figure 2. Schematic of dataflow within the Electronic Module Management System.

Materials and Methods

Work in 2017 focused on development of a data management utility (DMU) named "Cotton Module Data Management" and a scanning system for use on module trucks (Truck System) that automates the scanning and data collection process when modules are loaded or unloaded in the field or at the gin. The following sections detail the design and operation of these two systems as part of the Electronic Module Management System.

Data Management Utility (DMU)

The data management utility was developed to compile module specific data from HID Cotton Pro, RFID Module Scan, and the truck scanning system, and serve as a data hub from which the gin can transmit module pickup lists to transport vehicles and generate various reports for producers or ginners. Hardware requirements for the DMU include a PC running Windows 10 and an internet connection. The DMU builds an SQL data base containing all of the module information input via the HID Cotton Pro/Cotton Harvest File Download Utility, RFID Module Scan, and Truck Systems in addition to data manually input by users of the DMU. The SQL database is stored locally on the host PC in the gin office and can be backed up using external storage devices or third party providers. Data base tables containing client, farm, field, driver, and truck names in addition to tables containing load configuration settings, pickup lists, and module lists are also updated and stored on the "cloud" in a Microsoft Azure Document Database. The data stored in the "cloud" is accessed and appended to by the Truck System on a user defined frequency (typically one time per minute).

The DMU user interface is configured with multiple tabs located at the top of the screen that allow the user to view and input information required by the program. The "Home" tab (figure 3) displays general system summary information regarding the number of modules and loads in the system, remaining in the field, on the gin yard, and that have been ginned. The user can also run the import procedure from the Home tab to bring in new data from the Cotton Harvest File Download Utility (new HID files) and from RFID Module Scan. The "Settings" tab allows the user to specify GPS coordinates for the module feeder and storage yards, data update frequency used to push information to the "cloud", and import settings for data from the Cotton Harvest File Download Utility and RFID Module Scan app. Data on the "Settings" tab should be entered before the ginning season begins. The tabs titled "Clients", "Farms", "Fields", "Drivers", and "Trucks" contain name lists for each respective tab (figures 4-8). The DMU user can manually input names for clients, farms, fields, drivers, and trucks from the corresponding tab. Data for client, farm, and field names can be imported into the DMU lists from the HID files downloaded from the John Deere website via the Cotton Harvest File Download Utility. In order to promote the greatest level of data consistency throughout the season, it is recommended that the user manually input client, farm, and field names before harvest begins and confirm that the names are consistent between the DMU and HID files as the harvest data is imported.

🛃 Cotton N	Aodule Data Manag	ement									-	٥	×
Home	Pickup Lists	Modules	Clients	Farms	Fields	Drivers	Trucks	Reports	Settings	About			
Syste	m Summary	/											
Total m	odules in system:		17										
Total loa	ads in system:		5										
Modules	in the field:		17										
Loads in	n the field:		5										
Modules	on the yard:		0										
Modules	ginned:		0										
			Ret	fresh Cou	nts								
Impor	t Summary												
Last imp	port:	12/7/2017	7 10:00:08	AM									
Import S	itatus:	Import fini	ished.										
		Run	Imports		View App	lication Lo	g						

Figure 3. Home tab of the Cotton Module Data Management Utility.

💀 Cotto	n Module Data Mana	gement									-	٥	×
Home	Pickup Lists	Modules	Clients	Farms	Fields	Drivers	Trucks	Reports	Settings	About			
Refr	esh												
Refi	Client Ni Bill Willing Clint Sim	ame ms											
Ac	d Client Edi	t Selected	Delete C	hecked									

Figure 4. Client name input tab.

💀 Cotton I	Module	Data Manag	gement										-	۵	×
Home	Pic	kup Lists	Modules	Clients	Farms	Fields	Drivers	Trucks	Reports	Settings	About				
Searcl Client	h Filt	ers		Refresh											
	\checkmark	Client			Fam	ı									
Þ.		Bill Willia	ns		FSA	960									
		Clint Sim	ns		FSA	340									
Add	Farm	Edi	t Selected	Delete Cl	hecked										

Figure 5. Farm name input tab.

🛃 Cottor	Module Data Manag	jement									-	Ø	×
Home	Pickup Lists	Modules	Clients	Farms	Fields	Drivers	Trucks	Reports	Settings	About			
Searc Client	h Filters	1	Farm										
						Re	fresh						
	Client			Far	m			Field					
۱.	🔲 🛛 Bill Williar	ns		FSA	960			North Circl	le				
	Clint Sim	ns		FSA	340			South Drip	Block	_			
1													
1													
Ad	d Field Edit	Selected	Delete C	hecked									

Figure 6. Field name input tab.

🛃 Cotton	Module Data Mana	gement									 -	٥	×
Home	Pickup Lists	Modules	Clients	Farms	Fields	Drivers	Trucks	Reports	Settings	About			
Refres	h												
	First nan	ne Lastin	ame										
	Tom	Smith											
Add	Driver Edi	it Selected	Delete C	hecked									

Figure 7. Drivers name input tab.

💀 Cotton	Module Data Man	agement									-	٥	×
Home	Pickup Lists	Modules	Clients	Farms	Fields	Drivers	Trucks	Reports	Settings	About			
Refre	sh												
	Truck I	D		Loa	d Prefix								
۱.	Truck 1			T1									
	Truck 2			T2			_						
	Truck 3			T3			- 11						
Add	Truck	dit Selected	Delete C	hecked									

Figure 8. Truck name input tab.

Once the DMU user has input the necessary information into the "Settings", "Clients", "Farms", "Fields", "Drivers", and "Trucks" tabs, the user should return to the Home tab and click the "Run Imports" button to add new module data to the "Modules" tab (figure 9). On the "Modules" tab, the user can add, edit, or delete specific modules by checking the box next to the target module and then clicking the appropriate button at the bottom of the page. The user can also check the box next to a single module or a group of modules and click the "View Selected Module History" tab to see a listing of the module location history for each selected module. The "Assign Load to Checked" button is used to manually assign a load number to a module serial number in the event that it was not previously assigned (such as in the case of a conventional module or modules hauled in on a semi-truck that were not scanned

into a load in the field.) The "Modules" tab also contains search filters at the top of the page that can be used to sort and filter the modules by client, farm, field, serial number, load number, truck ID, or driver name. The filtered data can be sorted by date or by any of the previous fields in ascending/descending or time order. The "status" filter field can be used to only display modules with a given status such as "in field", "at gin", or "ginned."

💀 Cotton	Module Data Manag	ement													- 0	×
Home	Pickup Lists	Modules	Clients	Farms	Fields	Drivers	Trucks	Reports	Settings	About						
Searc	h Filters	Farm			Field			Serial	No	Load	#	Truck ID		Drive	,	
Status	Dat	to added after	Date	added befo	e Sort by	,										
Any	~ 11/	7/2017	12/ 7/2	2017	Serial	No No	ascend	ing order 🖂	Refres	h						
	Client	Farm	Field		Serial #	Load	1#	Imported Lo	ad #	Truck	Driver	Latitude	Longitude	Status	Added	Updat
Þ	📃 🛛 Bill William	ns FSA 960	North (Circle	1540869	9864		1				33.732272	-102.128933	In Field	12/7/2017 10:00:08 AM	
	Bill William	ns FSA 960	North 0	Circle	1540869	9865		1				33.732282	-102.128887	In Field	12/7/2017 10:00:08 AM	
	Bill William	ns FSA 960	North 0	Circle	1540869	9866		1				33.732292	-102.128897	In Field	12/7/2017 10:00:08 AM	
	Bill William	ns FSA 960	North (Circle	1540869	9867		1				33.732302	-102.128907	In Field	12/7/2017 10:00:08 AM	
	Bill William	ns FSA 960	North (Circle	1540869	9868		2				33.732312	-102.128917	In Field	12/7/2017 10:00:08 AM	
	Bill William	ns FSA 960	North (Circle	1540869	9869		2				33.732322	-102.128927	In Field	12/7/2017 10:00:08 AM	
	Bill William	ns FSA 960	North (Circle	1540869	9870		2				33.732332	-102.128937	In Field	12/7/2017 10:00:08 AM	
	Bill William	ns FSA 960	North (Circle	1540869	9871		2				33.732342	-102.128947	In Field	12/7/2017 10:00:08 AM	
	Bill William	ns FSA 960	North 0	Circle	1540869	9872		3				33.732352	-102.128957	In Field	12/7/2017 10:00:08 AM	
	Clint Simm	ns FSA 340	South I	Drip Block	1540869	9873		3				33.732362	-102.128967	In Field	12/7/2017 10:00:08 AM	
	Clint Simm	ns FSA 340	South I	Drip Block	1540869	9874		3				33.732372	-102.128977	In Field	12/7/2017 10:00:08 AM	
	Clint Simm	ns FSA 340	South I	Drip Block	1540869	9875		3				33.732382	-102.128987	In Field	12/7/2017 10:00:08 AM	
	Clint Simm	ns FSA 340	South I	Drip Block	1540869	9876		4				33.732392	-102.128997	In Field	12/7/2017 10:00:08 AM	
	Clint Simm	ns FSA 340	South I	Drip Block	1540869	9877		4				33.732402	-102.129007	In Field	12/7/2017 10:00:08 AM	
	Clint Simm	ns FSA 340	South I	Drip Block	1540869	9878		4				33.732412	-102.129017	In Field	12/7/2017 10:00:08 AM	
	Clint Simm	ns FSA 340	South I	Drip Block	1540869	9879		4				33.732422	-102.129027	In Field	12/7/2017 10:00:08 AM	
	Clint Simm	ns FSA 340	South I	Drip Block	1540869	9880		5				33.732432	-102.129037	In Field	12/7/2017 10:00:08 AM	
<																>
Add	Module Edit	Selected	View Se	lected Mod	ile History	Delete	Checked	Assign	load to che	cked						

Figure 9. Modules tab displaying modules currently in the system.

The "Pickup Lists" tab (figure 10) is used to generate and edit lists of modules to be hauled into the gin. The user can check the box next to a pickup list they wish to edit or delete and click the appropriate button at the bottom of the screen. To add a new list, the user clicks the "Add List" button at the bottom of the screen, enters a new name for the list, and selects client, farm, and field names from the drop down lists. The screen displays all available module serial numbers for that client/farm/field combination. The user can select all or any subset of the displayed module serial number list and click "next" to add the modules to the pickup list. The last task is to select the truck or trucks to assign the list to before clicking "Save" to send the new pickup list to the trucks.

In the event that no module serial numbers are available for a selected client, farm, and field, the system displays a Google map (figure 11) that is used to identify the field location to which to send the trucks (e.g. in the case where a number of round modules are verbally called into the gin or when a producer calls in a set of conventional modules to be hauled). The user clicks on the map location of the field to drop a "pin" indicating the field location and clicks next to select the trucks to transport the modules. Since the new list contains no module serial numbers, the Truck System will only display the directions to the field (pin location) where the modules are located and the driver must add the modules to the list when they are loaded.

🔛 Cotton Module Data	Add Pick	up List					×	- 0	×
Home Pickup L	i: Li:	st name:	List 001						
Search Filters		Client	Bill Williams ~	Farm: FSA 960	 ✓ Field: North 	Circle ~			
							g or	der 🗸	
	Pleas	se check	the module to include in this list.						
Refresh			Serial #	Status	Latitude	Longitude			
	- F		15408699864	In Field	33.732272	-102.128933			
List			15408699865	In Field	33.732282	-102.128887		Total Loa	ds
			15408699866	In Field	33.732292	-102.128897			
			15408699867	In Field	33.732302	-102.128907			
			15408699868	In Field	33.732312	-102.128917			
			15408699869	In Field	33.732322	-102.128927			
			15408699870	In Field	33.732332	-102.128937			
			15408699871	In Field	33.732342	-102.128947			
			15408699872	In Field	33.732352	-102.128957			
٢									>
							'		
Add List	N	lext	Cancel						

Figure 10. Pickup list tab showing the available modules for the selected client, farm, and field.



Figure 11. Map screen presented to the DMU user when no modules are available for the selected client, farm, and field. The user simply clicks on the map to drop a pin on the field location for where to send the trucks.

Report generation in the DMU is accomplished on the "Reports" tab (figure 12). The user can simply filter the available module list in the system to create a filtered and sorted list of modules to print or they can run a customized export routine to generate report documents in PDF or .csv file formats. To export data from the DMU, the user selects the export type from the drop down menu, types in a name for the report header, and clicks export. Custom reports can be created by defining the database fields and column order layout in a .csv file template. To export data using the custom report format, the user selects the .csv export type and selects the template name from a drop down list. The template files are stored in a file on the DMU PC hard drive and can be modified to fit any

needed data structure.

💀 Cotton I	Module Data Mana	gement													-	٥	×
Home	Pickup Lists	Modules	Clients	Farms	Fields	Drivers	Trucks	Reports	Settings	About							
Filter	Options																
Client		Fan	m		Fiel	d		Seria	l No	Load#		Truck ID		Driver			
Status	Г)ate added aft	er Date	added befor	re Reco	rds to show			rt by			Then by					
Any	~ 1	1/ 7/2017] ▼ 12/ 7/	/2017	All loo	ation record	s	~ Tir	nestamp	~ ascendin	g order 🖂	 Serial No 	~ ascend	ling order $\!$			
Then by	у																
Field	√ a	scenaing oraei	r v														
Export T	t Options	Depert Title															
PDF Lis	st ~	Module Locati	ion History														
Ехро	rt																

Figure 12. Filtered data and customized reports are generated on the "Reports" tab in the DMU.

Module Truck Based RFID Scanning System (Truck System)

The truck based RFID scanning system (Truck System) utilizes an RFID reader and antennas located in the bed of the vehicle to scan the module RFID tags as they are loaded or unloaded. The truck software (operating on a PC in the vehicle cab) receives "Pickup Lists" from the DMU running on a PC in the gin office via the "cloud" based Azure Document database. Communication between the DMU and the Truck System is accomplished wirelessly over a Wi-Fi or cellular connection.

The Truck System software was designed with a "tab" layout similar to the DMU software making it easy for the truck operator to manipulate the software through a touch panel display. The "Home" screen of the Truck System software (figure 13) displays the pickup lists that have been transmitted to the truck and allows the user to sort the available lists by client, farm, and field. The user can also add a new list from the home screen in cases where the module pickup list is not transmitted prior to the truck arriving at the field. To open a pickup list, the user taps on a list shown on the "Home" screen and then taps "Open Selected." When the pickup list opens, a map displaying the last location for each module on the list appears (figure 14). The map screen shows the current client, farm, and field along with the number of modules and loads to be hauled and that have been hauled. The system will generate driving directions for the driver when they tap the "Directions" button on the top right side of the screen.

Once the truck arrives at the field and begins loading modules on the pickup list, the screen displays the image shown in figure 15. In the case where modules are loaded with serial numbers not matching those on the pickup list, the screen displays the image shown in figure 16. Once the loading process is stopped (i.e. the bed chains stop) the user is prompted with the message shown in figure 17 to either "Unload and Start Over" or "Continue Loading." Selecting the "Unload and Start Over" button changes the screen image to that shown in figure 18 where the system waits to see the erroneously loaded module RFID tags leave the truck. Pressing "Continue Loading" changes the screen to the image shown in figure 19 where the user adds the module serial numbers to a new or existing list.

When the module loading process is complete, the truck software assigns a load number to the group of modules to be used in tracking seed cotton, lint, and seed weights through the ginning process. The format of the load number assigned by the truck is specified in the "Truck" tab (figure 13) and contains a static prefix string (generally indicating the year and or truck number) along with a never-repeating unique load serial number that auto-increments for each new load. The data management utility updates the "status" of the module each time it is loaded

or unloaded depending upon its physical location. For example, GPS coordinate boundaries are input into the data management system for the gin module storage yard allowing the system to detect when a module is loaded or unloaded on the gin yard. In this case, the status would change to "At Gin" when unloaded on the yard (figure 20).

Wireless communication settings for the Wi-Fi and/or cellular network are configured on the "Data Sync" tab along with the frequency at which the Truck System synchronizes information with the database in the cloud. GPS receiver and RFID reader and antennae settings are configured on the "Hardware" tab on the Truck System display.

Home Truck Data Sy	nc Hardware		Lock Settings	Tom Smith ~
All Clients ~ All Farm	ns · All Fields	+Add List Open Sele	ected	Sync Exit
Client	Farm	Field	List Name	
Bill Williams	FSA 960	North Circle	List 001	
Clint Simms	FSA 340	South Drip Block	List 002	
Clint Simms	FSA 340	North Drip	List 003	

Figure 13. Truck system "Home" screen showing all available pickup lists.

List 001			Position: 33.529251, -101.910489
Client: Bill Williams Modules in field: 9 Loads remaining: 3	Farm: FSA 960 Field: North Circle Modules loaded: 0 Modules on list: 9 Loads Completed: 0		Directions Close
Map Satellite			
			● +
Google		Mapdite ©	2017 Google Inlagery \$2017, Treinir of User Lifsport Freigierror.

Figure 14. Map showing current locations for all modules on the current pickup list.



Figure 15. Loading screen that appears when modules with serial numbers on the current pickup list are loaded.

List 001			Position: 33.529218,	-101.910440
Client: Bill Williams Modules in field: 5 Loads remaining: 2	Farm: FSA 960 Modules loaded: Loads Completed	Field: North Circle 0 Modules on list: 9 : 1	Directions	Close
Map Sarellite		WARNING: MODULE NOT ON LIST Current List: Bill Williams - FSA 960 - North Circle - List 001 Modules on Truck 15408699880 15408699879 Not on list 15408699880 15408699879		B
Google			Map data #2017 Octogle Terms of U	e Report a map error

Figure 16. Loading screen indicating that modules with serial numbers not on the current pickup list have been loaded (shown in red). Modules correctly loaded have serial numbers displayed in green.



Figure 17. Loading screen waiting for user input to either unload the modules not on the list (unload and start over) or to "continue loading" and add the modules to the current list.



Figure 18. Truck system screen waiting to unload modules that were not on the current pickup list.

List 003					1	Position: 33.529143,	-101.910470
Client: Clint Simms	Farm: FSA	Assign Modules to New List				Disettore	Class.
Modules in field: 0	Modules loa	Current Pickup List	nt Simms A 340 Client	gn to New List		Directions	
Loads remaining: 0	Loads Comp	FSA 340		Clint Simms	3		
Map Seculite		North Drip List 003					12
		Modules on Truck	Farm	FSA 340	~		
		15408699883	Field	North Drip	~		
		15408699882					
		15408699881	List	List 003	2		
				Save Cancel			8
Gongle					85	g data 42017 Brogle – Terma el Un	• Report e may enter

Figure 19. Truck system screen adding modules to a new list.

Home Truck Data Sy	nc Hardware			95 Tom Smith -
All Clients All Farm	All Fields	+Add List Open Selec	ted	Sync
Client Bill Williams	Farm FSA 960	Field North Circle	List Name List 001	
Clint Simms	FSA 34 FSA 34 Location: Gin Yard Modules on Truck 15408699872	le(s) 3 15408699871 15408699870	15408699869	
		Unloading 15408699872	2	

Figure 20. Truck system unloading screen indicating the modules are being unloaded at the gin yard.

The hardware components used to develop the Truck System are shown in table 2. The total cost to install the RFID scanning system on each module truck is approximately \$6,546. The components shown in table 2 were selected to provide adequate reliability for testing purposes. Additional testing is needed to evaluate the reliability of other lower cost alternatives. The Truck System and DMU software were both developed under an open source license and can be obtained free of charge from the authors.

Component	Supplier/Model	Cost
GPS Receiver	Ublox, EVK-7	\$250
Shaft Encoder (differential)	US Digital, HD25	\$537
Quadrature to USB Adapter	US Digital, QSB-D	\$100
UHF Gen 2 RFID Reader	atlasRFID.com, Impinj, R420	\$1585
RFID Antenna (2 required)	atlasRFID.com, Laird S9025PR	\$125 x 2 = \$250
Ruggedized Windows 10 PC	Logic Supply, Nuvo-5100VTC with	\$2489
	integral 4G LTE cellular modem	
Touchscreen Display	Xenarc, 1029CNH 10.1"	\$835
Cables, mounts, and enclosures		\$500
	Estimated Total (per truck)	\$6,546

Table 2. Components used in the module truck based RFID scanning system (Truck System).

Summary

The addition of the Truck System and DMU to the Electronic Module Management System in 2017 completes the basic system framework needed to track and manage module specific harvest data and location information from the time a module is wrapped in the field to the time it is placed on the module feeder for ginning. This system allows ginners and producers to move away from the labor intensive and tedious task of manually tagging or marking modules. This system can help optimize module transportation logistics by mapping current module locations in a field or on the gin yard and providing explicit directions to drivers. The components in the electronic module management system have been developed to work together as a complete system or in any combination of components that best fit a particular gin scenario. Additional development and testing of these systems is planned to further enhance the ability for producers to utilize fiber quality data in their site specific management strategies for cotton.

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