PRESENTATION

Session: **Cotton Breeding, Production, Ginning**

Title: **RFID Applications in Cotton Ginning**

Speaker: **Bobby Hardin,** Texas A&M University, USA

Presentations are available in the conference archive: https://baumwollboerse.de/en/competencies/international-cotton-conference/speeches/

Conference Organization

Faserinstitut Bremen e.V., Bremen, Germany. E-Mail: conference@faserinstitut.de
Bremer Baumwollboerse, Bremen, Germany. E-Mail: info@baumwollboerse.de

BIOLOGICAL & AGRICULTURAL ENGINEERING
TEXAS A&M UNIVERSITY

RFID Applications in Cotton Production and Ginning

Robert G. Hardin IV
Zafar Iqbal
Tianyi Wang
Edward M. Barnes
John D. Wanjura
Jason K. Ward

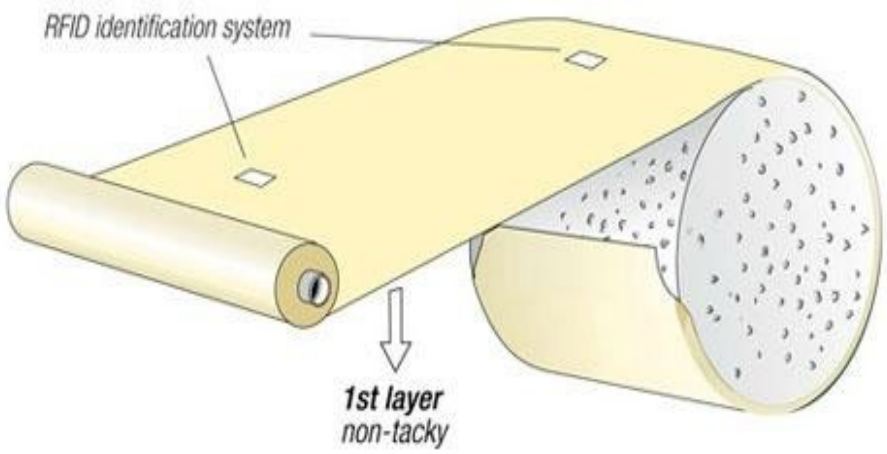
Texas A&M University
Texas A&M University
China Agricultural University
Cotton Incorporated
USDA-ARS

Round Module Cotton Harvesting System

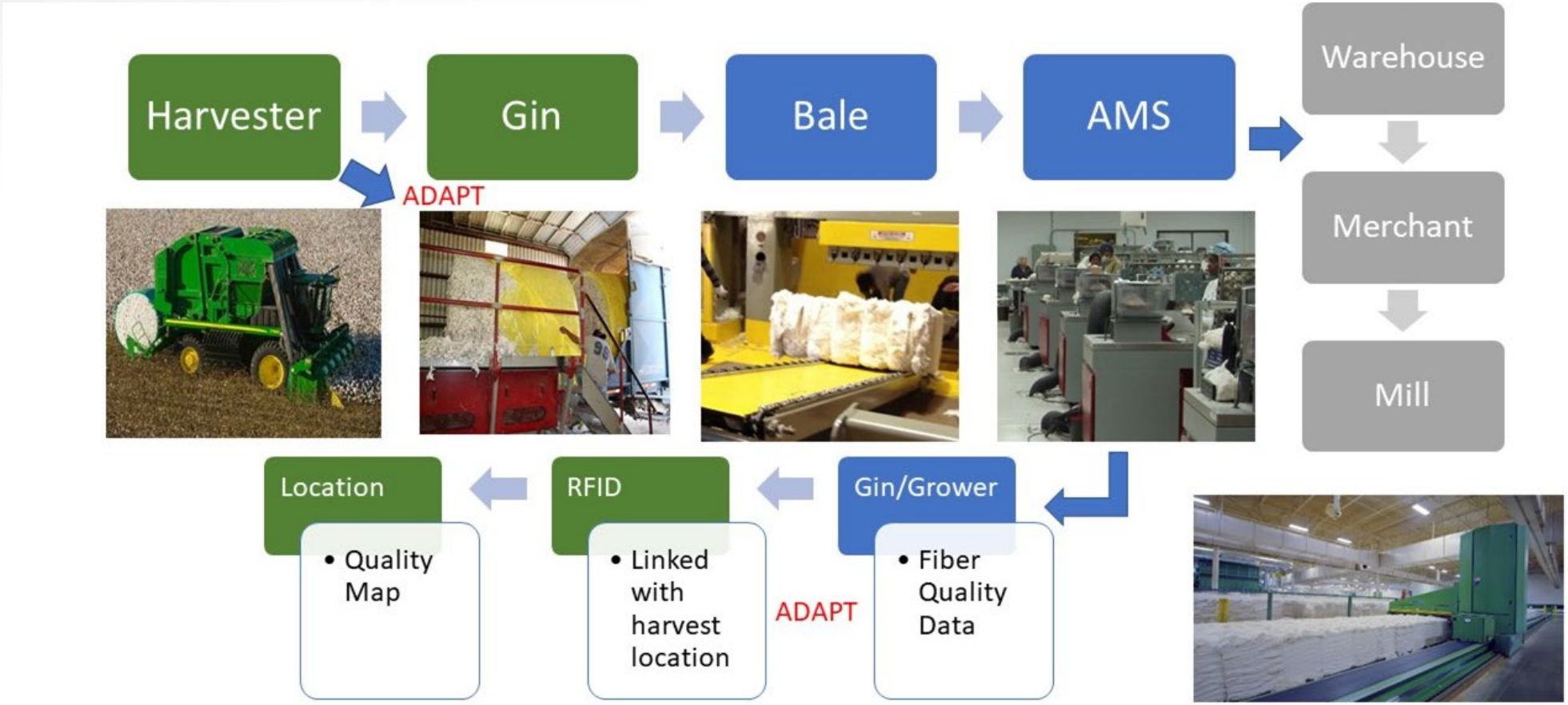
- Majority of cotton harvested in US
- Reduced harvesting labor from 1.5 hr/ha to 0.4 hr/ha
- 2500 kg modules (on newest models), wrapped in plastic film with integral RFID tags

Opportunities with RFID

- Link data from field to gin (and beyond)
- Easily integrate additional sensor measurements in gin process control systems
- Automated inventory management at gin
- Current utilization of RFID data is limited



Current Data Flow in Cotton Harvesting and Processing



Challenges with Round Module System

- Plastic contamination
- Moisture
  - Modules are better protected from rain, but reduced moisture exchange with ambient air can create problems
- Logistics


Production


Staging


Loading


Trailer Transport


Unloading


Gin yard staging


Truck transport


Deliver to module feeder

Objectives

Overall goal: Develop data-driven management practices to increase gin efficiency and improve fiber quality.

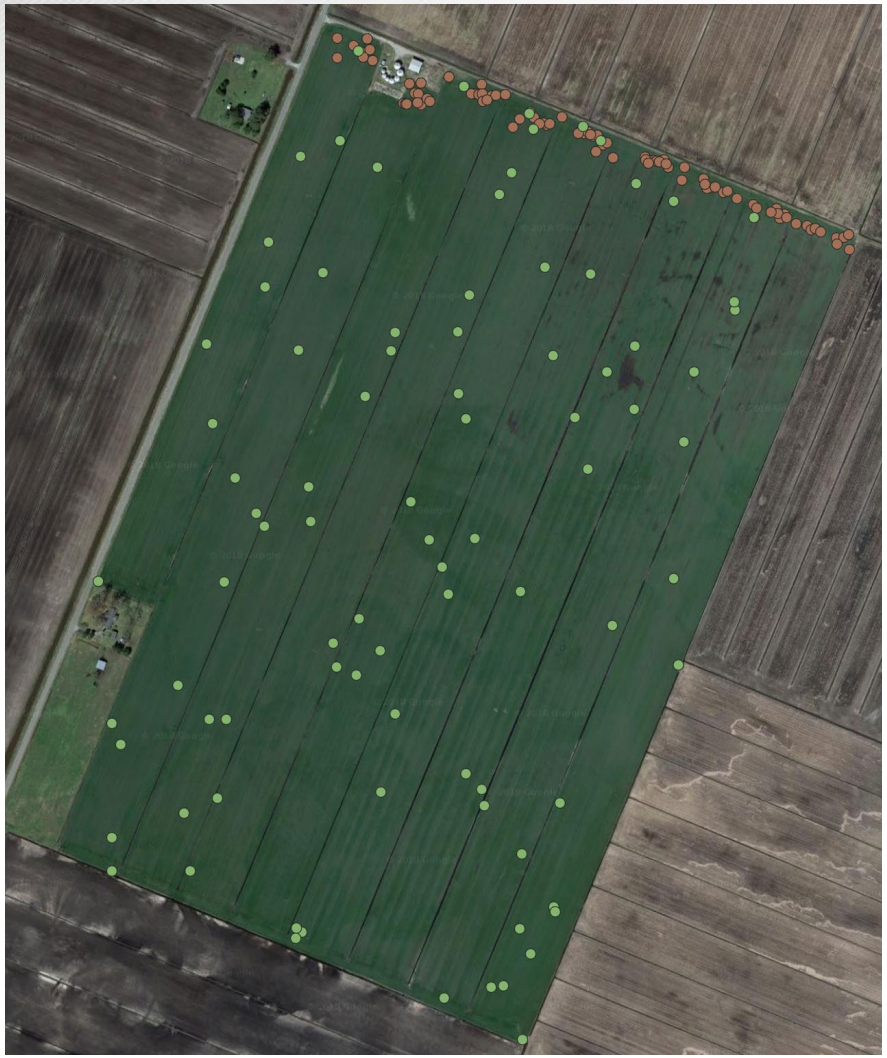
1. Map fiber quality to field locations.
2. Optimize logistics of round module handling.
3. Automate detection of wrap damage.
4. Develop a round module moisture measurement system.
5. Develop tools to integrate RFID data with gin management software.

Machine Data Streams

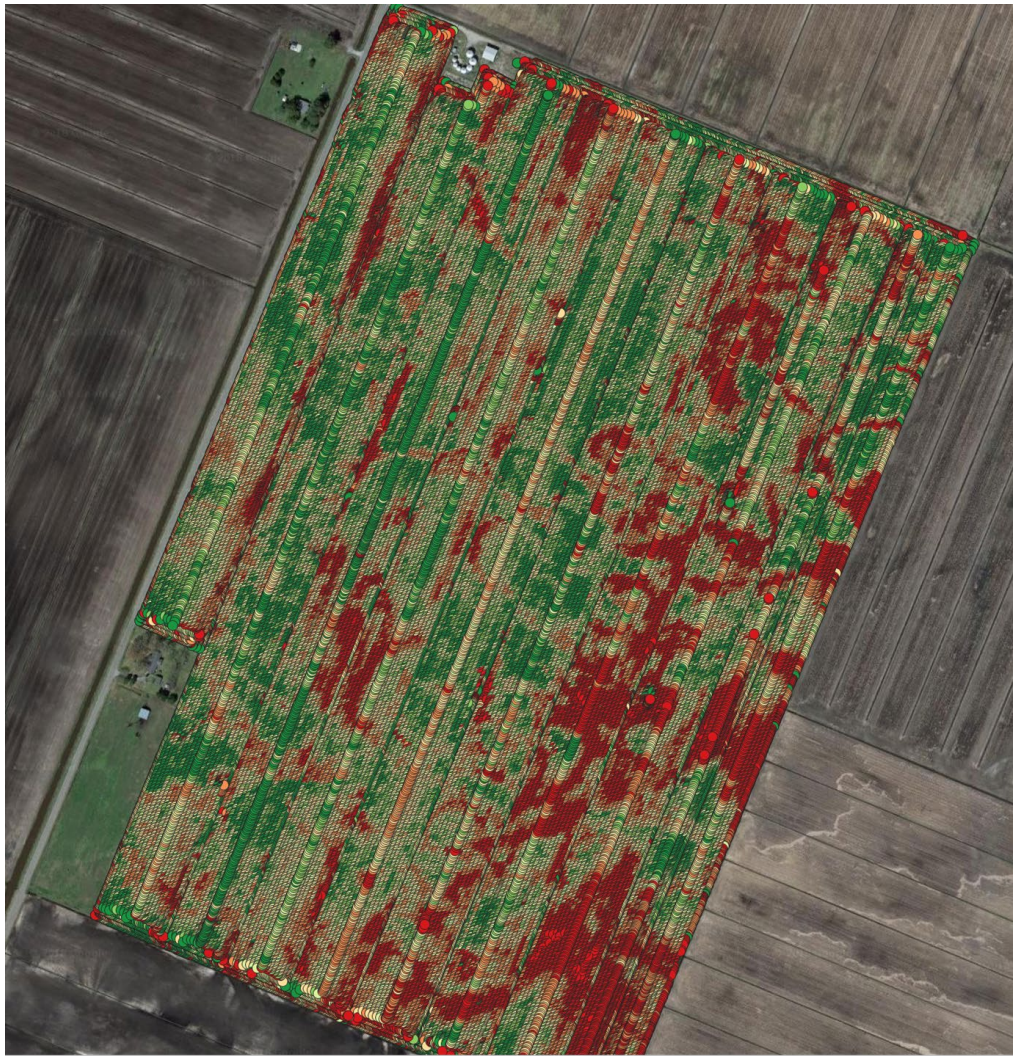
- Generated by cotton harvester
  - Yield Maps
  - Harvest ID (HID) file

module_id	module_sn	Lat	Lon	GMT_Date	GMT_Time	Tag_Coun	Client	Farm	Field	Variety	Machine_	Operator	Gin_I
3500B98806110B040D51E36D	17403339629			11/22/2018	23:32:09	11				MIX	1N0C690P		
3500B98806110A040D51E36C	17403339628			11/23/2018	0:21:35	11				MIX	1N0C690P		
3500B988061109040D51E36B	17403339627			11/23/2018	0:43:52	11				MIX	1N0C690P		
3500B988061108040D51E36A	17403339626			11/23/2018	1:09:44	11				MIX	1N0C690P		
3500B988061107040D51E369	17403339625			11/23/2018	1:35:54	10				MIX	1N0C690P		
3500B988061106040D51E368	17403339624			11/23/2018	1:54:13	10				MIX	1N0C690P		
3500B988061105040D51E367	17403339623			11/23/2018	2:16:59	10				MIX	1N0C690P		
3500B988061104040D51E366	17403339622			11/23/2018	2:51:52	11				MIX	1N0C690P		
3500B988061103040D51E365	17403339621			11/23/2018	3:15:29	10				MIX	1N0C690P		

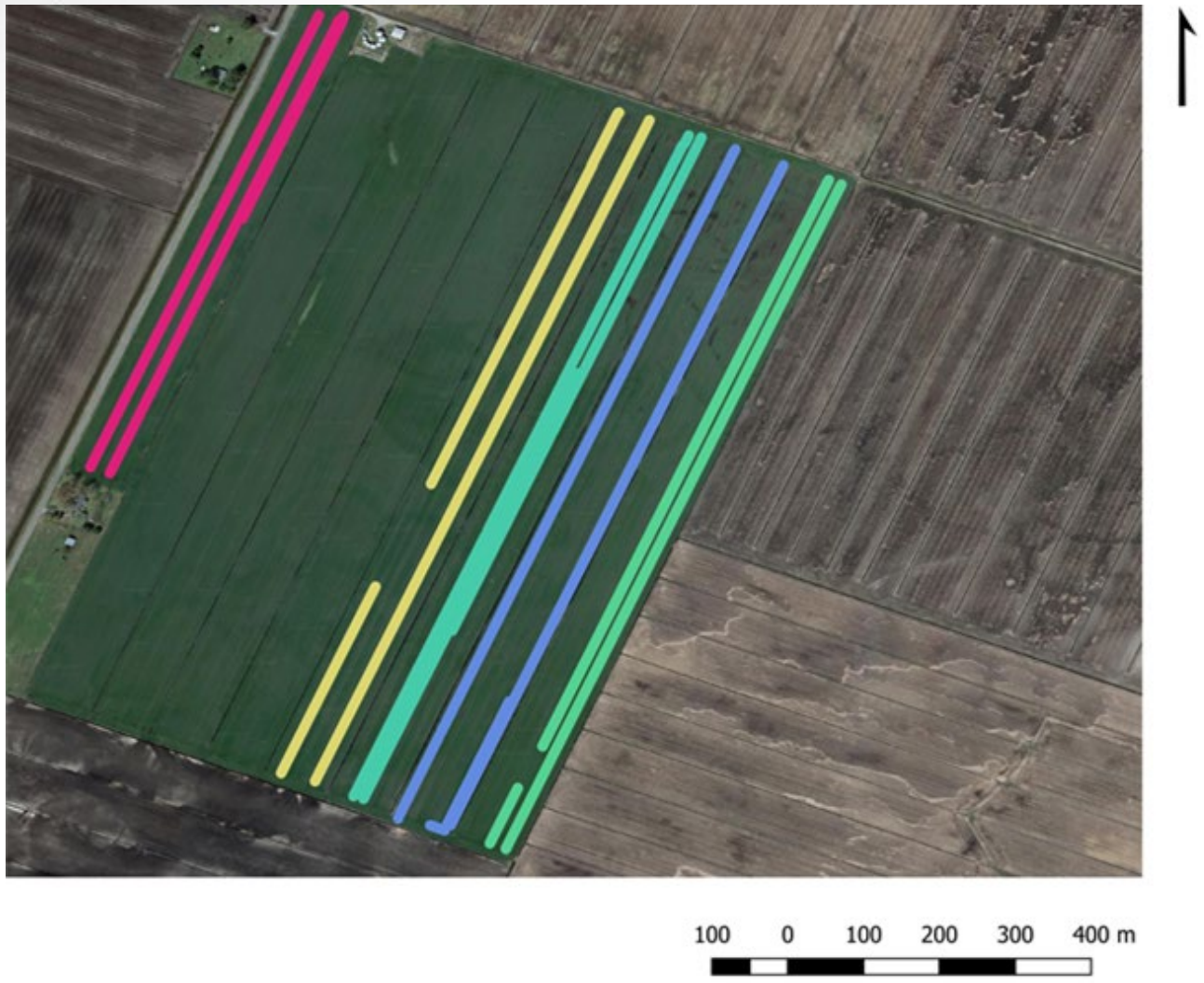
HID File



Yield Map



Discrete Module Path



Gin Data Streams

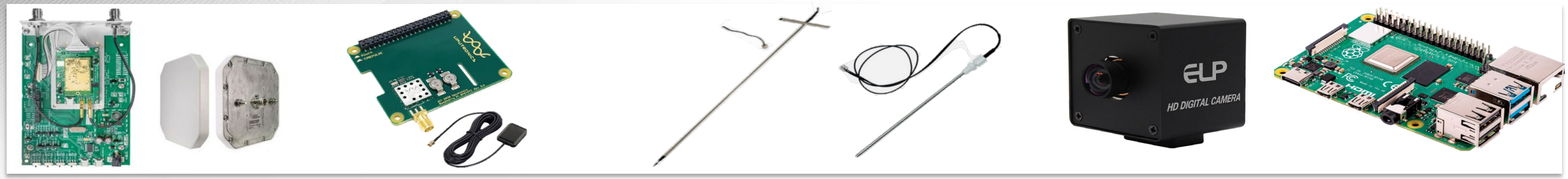
- Classing data by Permanent Bale Identifier (PBI)
- Gin software associates each bale with the module it was produced from
  - Average data from bales in a module

Load #	Serial ID	Bale #	Weight
3231	17403339554		516
3231	17403339554		525
3231	17403339554		524
3231	17403339554		521
3231	17403339554		501

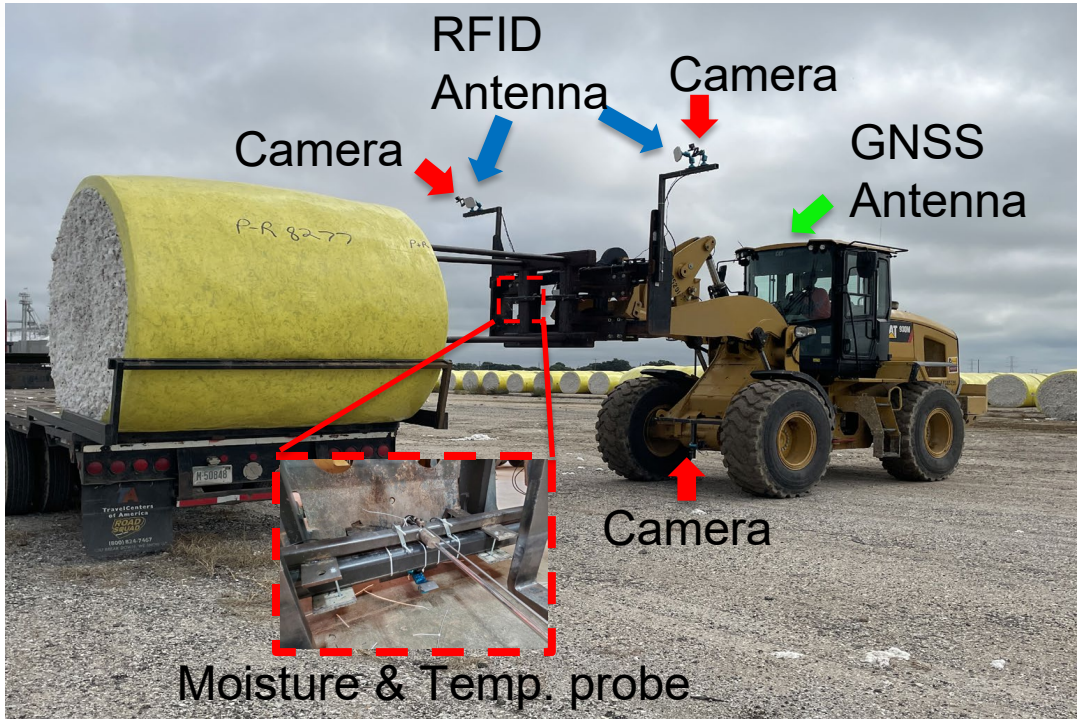
Gr	L	St	Mic	Strn	CGr	Len	Unif	Value	CValu	BlValu
41	4	38	4.7	32	41-1	119	82	54.35	235	278.27
31	3	37	4.8	34.1	31-2	116	83.8	56.5	450	294.37
41	4	37	4.8	35	41-1	117	83.9	54.5	250	283.4
41	4	38	4.7	34	41-1	118	83.3	54.55	255	282.02
41	3	37	4.8	34.4	41-1	116	84.2	55.15	315	274.1
31	4	37	4.8	33.7	31-2	114	81.8	54.95	295	270.9
31	3	37	4.8	34.1	31-2	115	82.5	56.4	440	282
41	4	37	4.8	33.5	41-1	117	83.2	54.5	250	279.04
41	3	37	4.9	33.5	41-3	115	83.3	55.05	305	275.8
31	4	37	4.9	32.6	31-2	116	83.1	55	300	272.25
31	3	37	4.8	32.7	31-2	115	83	56.4	440	276.92

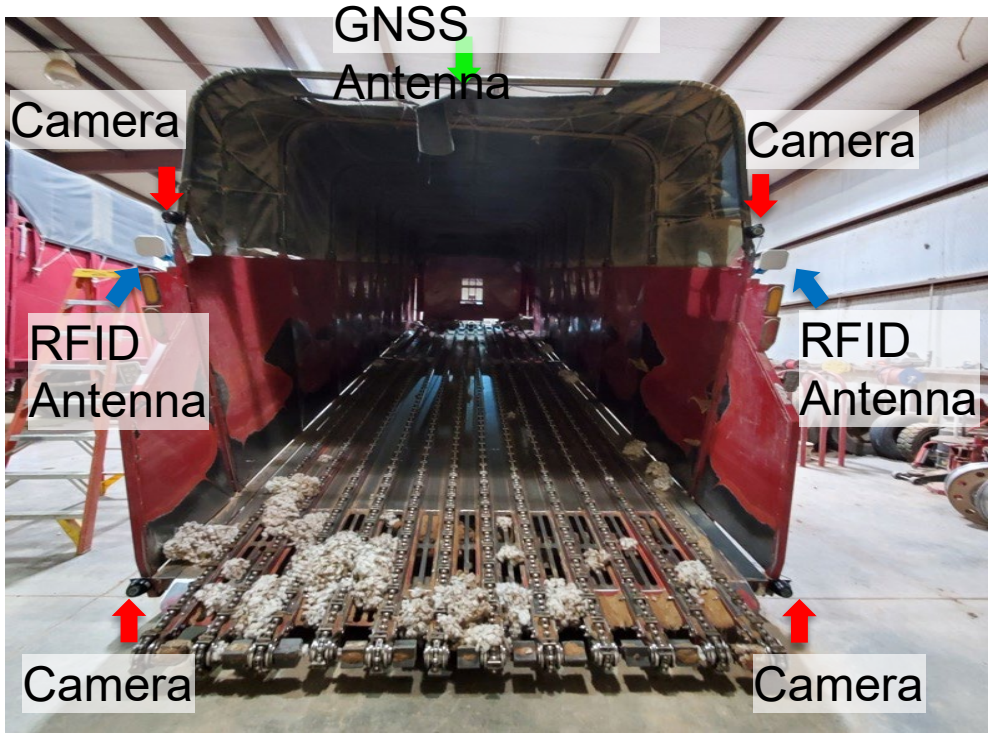
Micronaire Map

Cotton Module Monitoring System



RFID module | GNSS module | Moisture & Temp. probe | Camera | Raspberry Pi 4 B





Wrap Damage

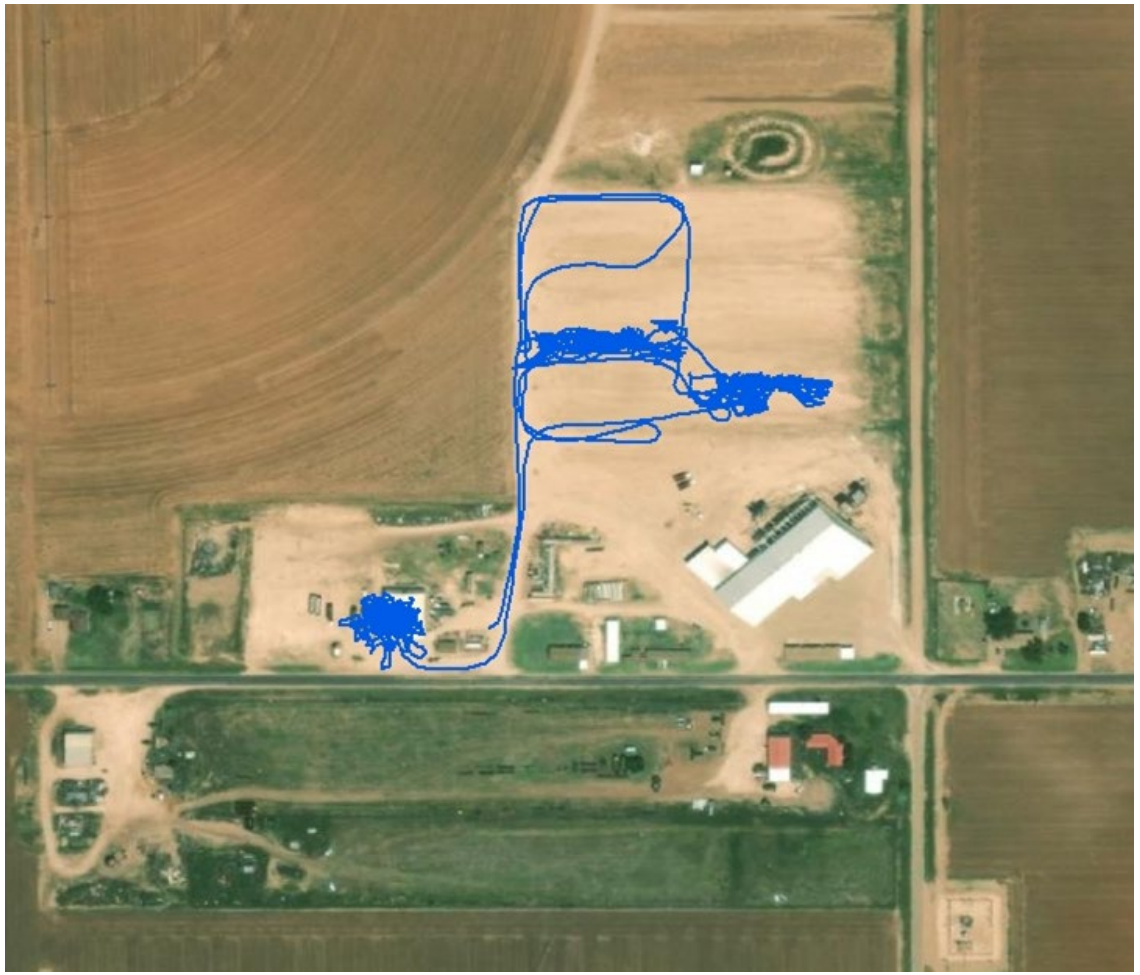
(a)

(b)

(c)

(d)

Module Tracking at Gin



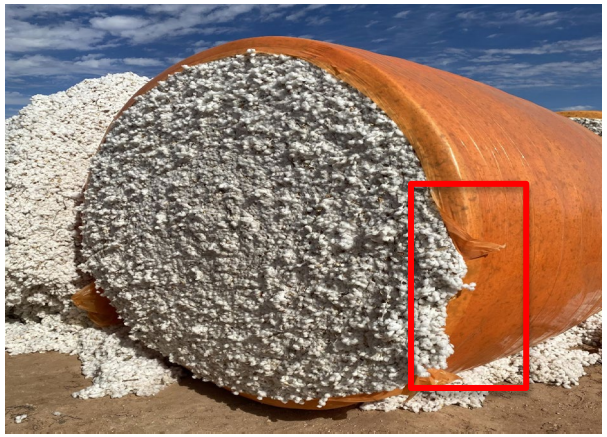
Gin Logistics

Gin	Operations	Modules Handled	Route	Time per Module	% Time Loader Moving	Wrap Damage
1	7	481	28.9 mi	1.46 min	33.3%	3.12%
2	16	1,961	61.6 mi	1.73 min	29.6%	4.18%

- 2021 data similar to previous seasons
- Loader used for handling at the gin spends ~60% time idle
  - Potential for more efficient use of labor/machinery but requires coordinated logistics
- Wrap damage at studied gins has averaged 3-4%
  - All gins have been experienced in handling round modules

Deep Learning for Wrap Damage Detection

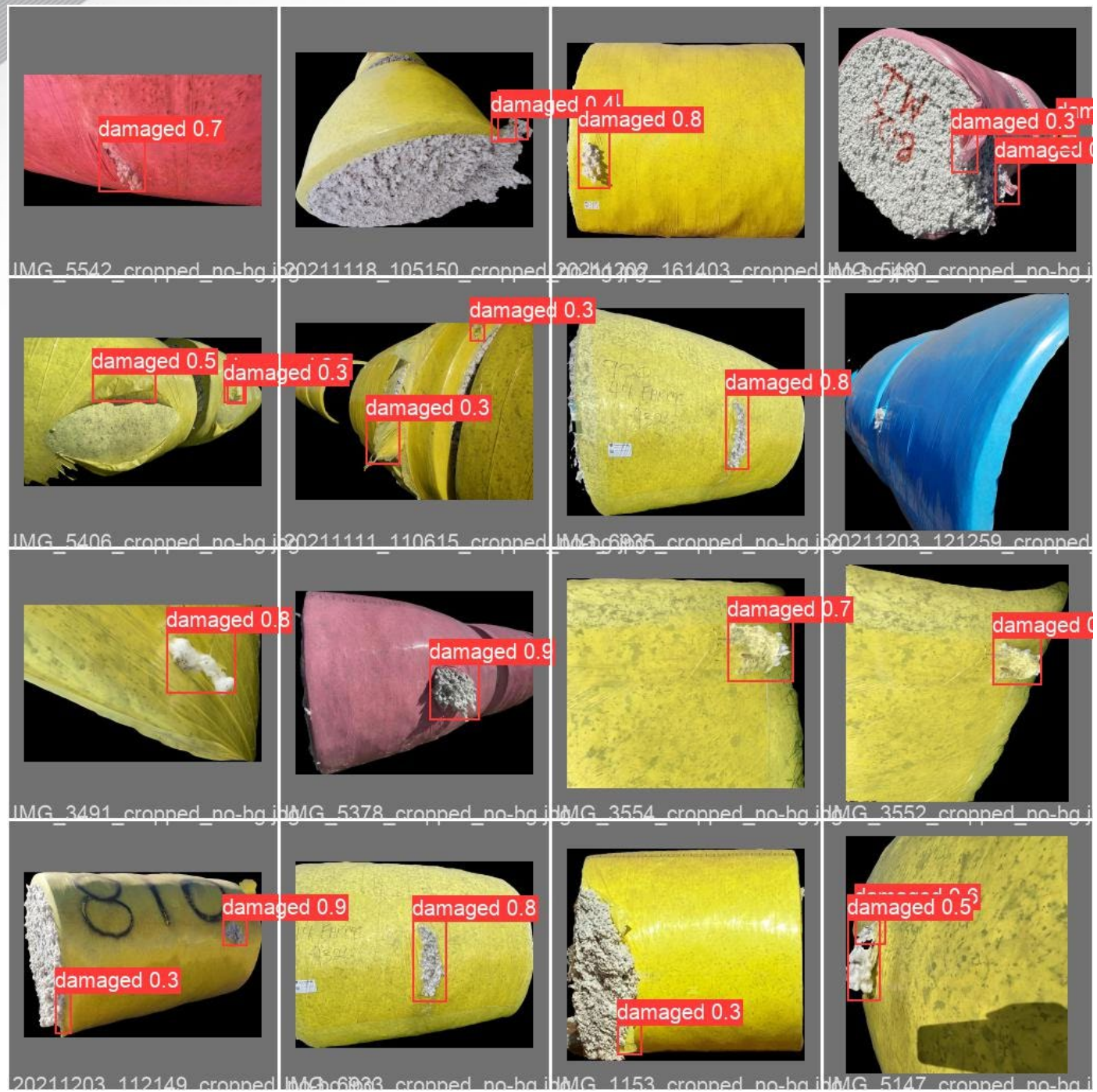
- Automatically identify damaged modules to alert management for need for special handling
- Using YOLO v5 to identify areas of damaged wrap
  - Background objects (clouds, other modules) resemble loose cotton, resulting in misclassifying some modules as damaged
- Used U2-net for background removal
- Trained and validated model, tested on both images captured manually and with module monitoring system



Module Monitoring System Images- Background Removal

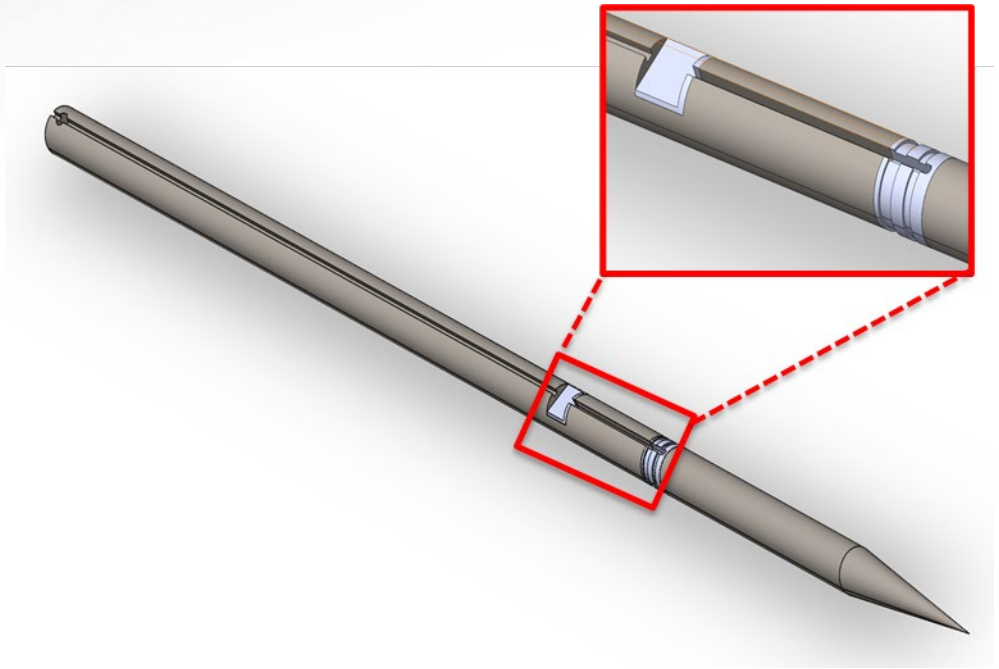
- More challenging detection problem
- Background removal improved accuracy on test data set to 78.4%

- Phone camera images
- Accuracy on test data set = 82.4%

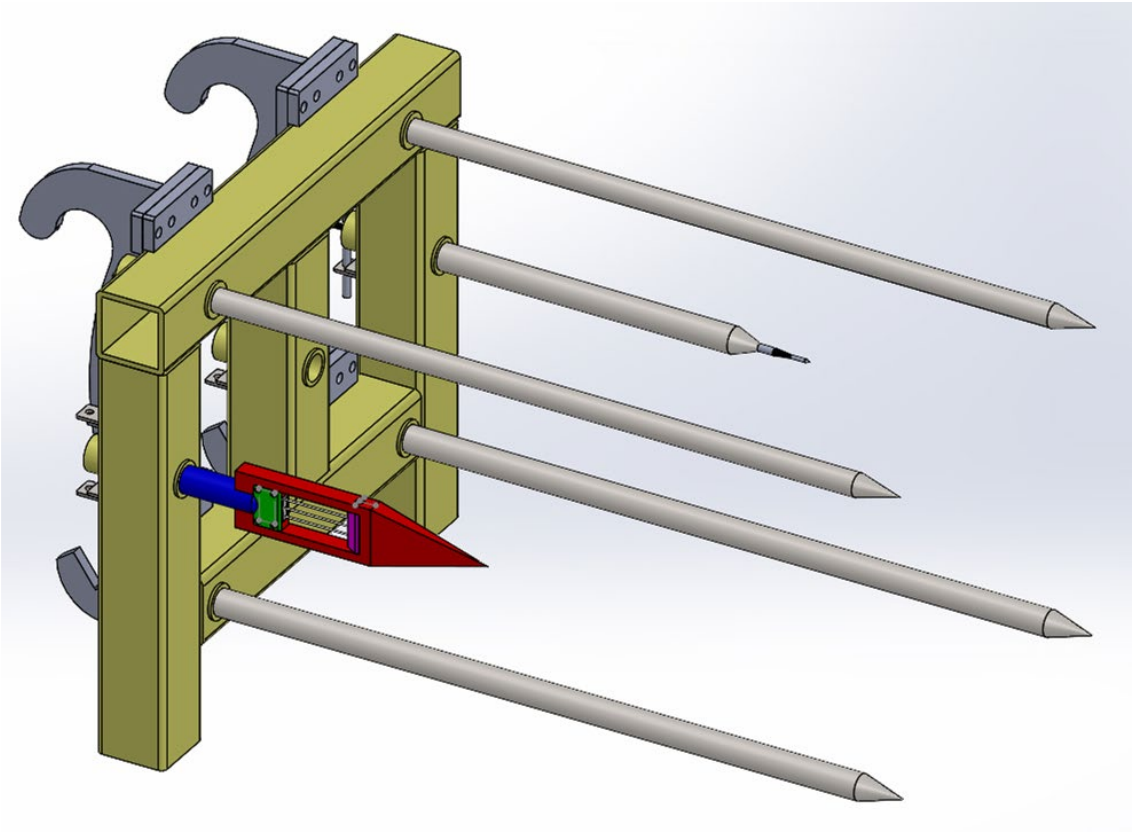


Moisture Sensing on Loader

Integral Resistance-Based



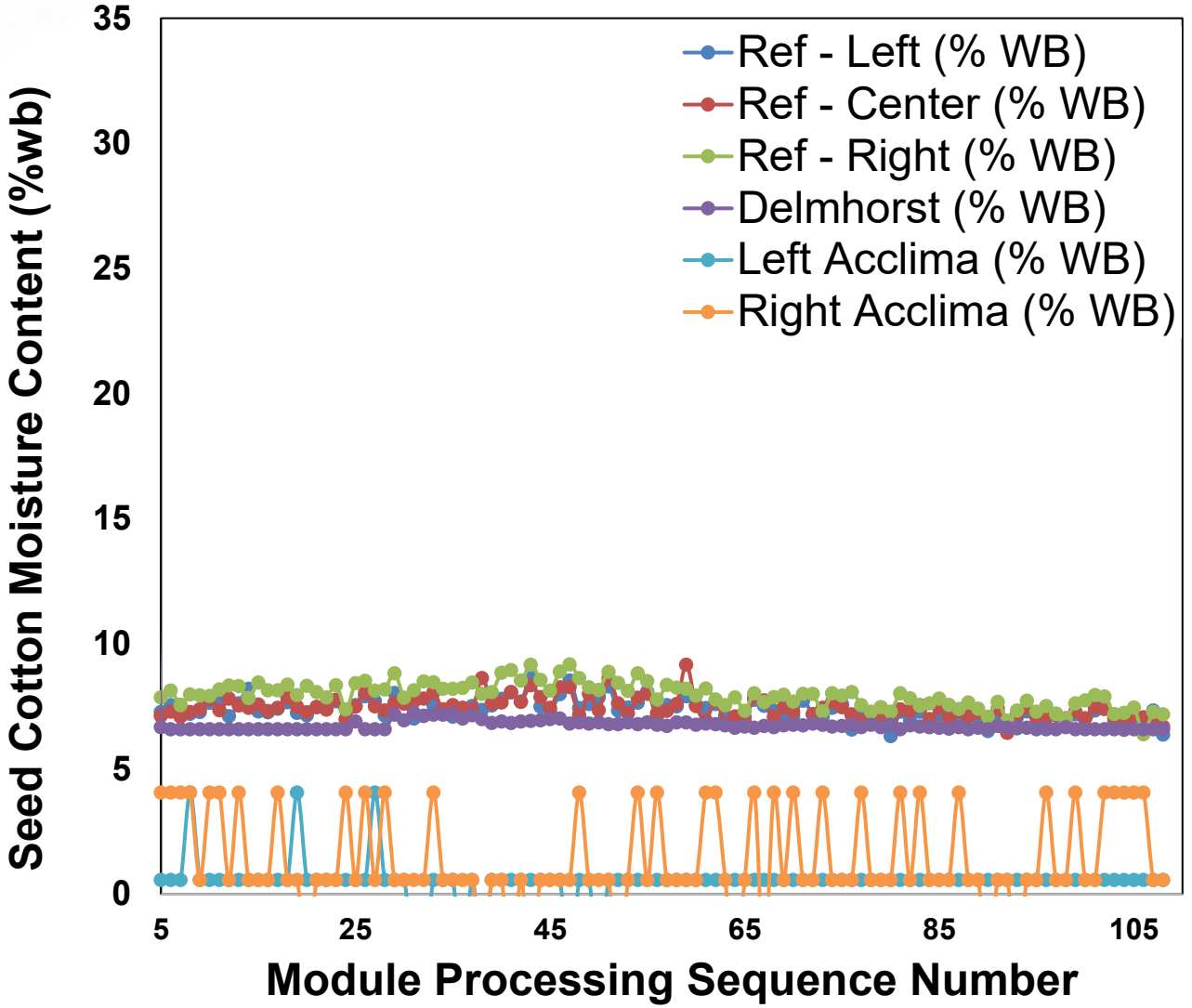
Add-on Resistance and TDR Microwave Probes



- Delmhorst resistance probe
- Acclima TDR microwave sensors

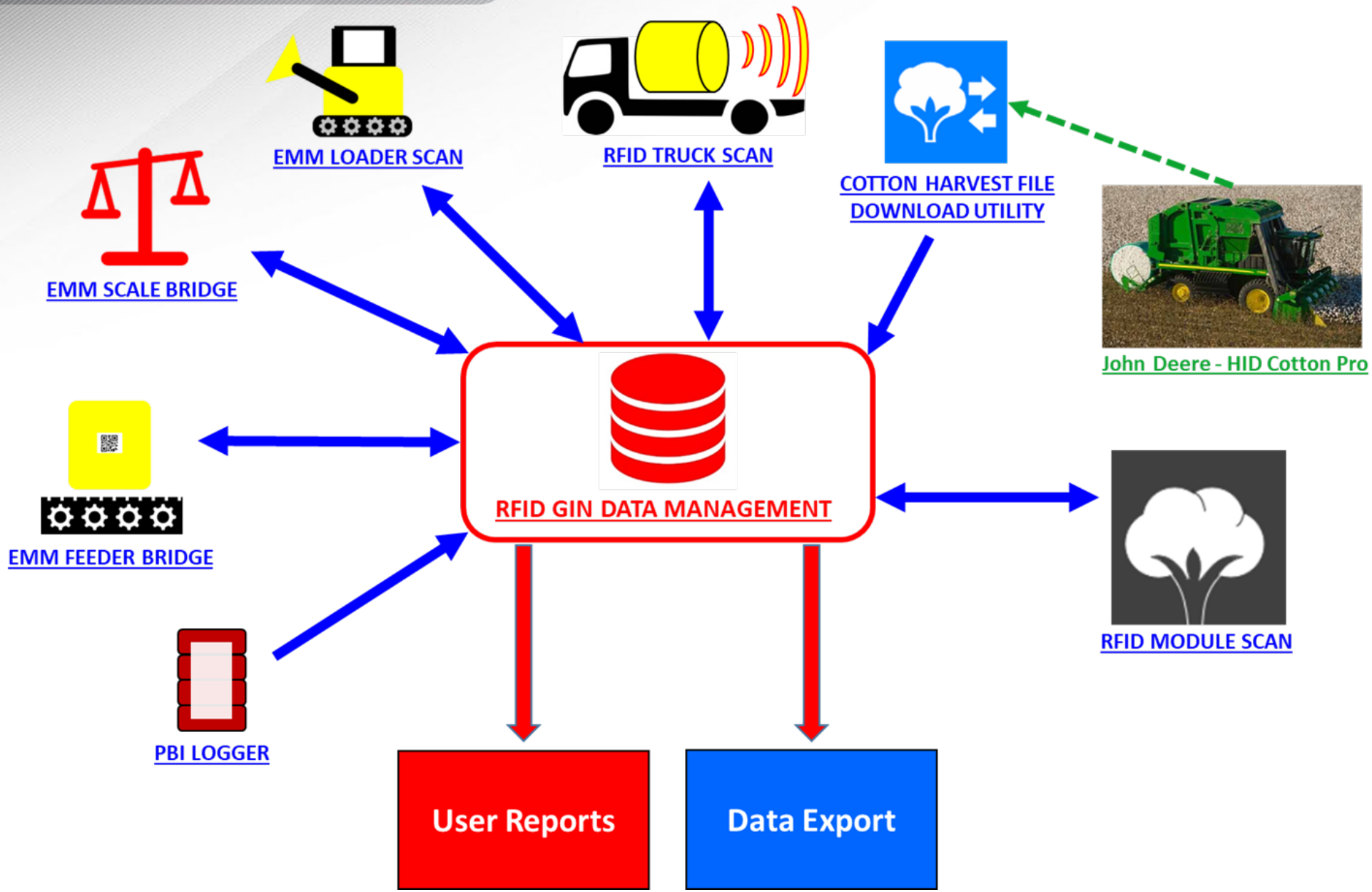
Preliminary Moisture Sensing Results

- Delmhorst resistance probe tracked reference moisture values more closely than TDR probes
  - TDR probe holder is being redesigned to improve exposure to cotton
- Seed cotton was dry and the range in reference moisture values was small and likely inadequate to draw conclusions



RFID Gin Data Management Utility

- Previous solutions are research-driven
  - Need tools to facilitate use of RFID technology by ginners and growers
- USDA-ARS worked collaboratively with a software developer to create an open-source database utility that compiles all HID data, module scan information, PBI Logger data, and facilitates transportation logistics
- Hardware and Setup
  - Windows 10 PC running in gin office
  - Setup client, farm, field, driver and truck names pre-season
  - Setup naming convention for load names
  - Input GPS boundaries for module storage yards and module feeder
  - Import settings for HID Download Utility and RFID Module Scan


EMM LOADER SCAN
RFID TRUCK SCAN
COTTON HARVEST FILE DOWNLOAD UTILITY
EMM SCALE BRIDGE
John Deere - HID Cotton Pro
RFID GIN DATA MANAGEMENT
EMM FEEDER BRIDGE
RFID MODULE SCAN
PBI LOGGER
User Reports
Data Export

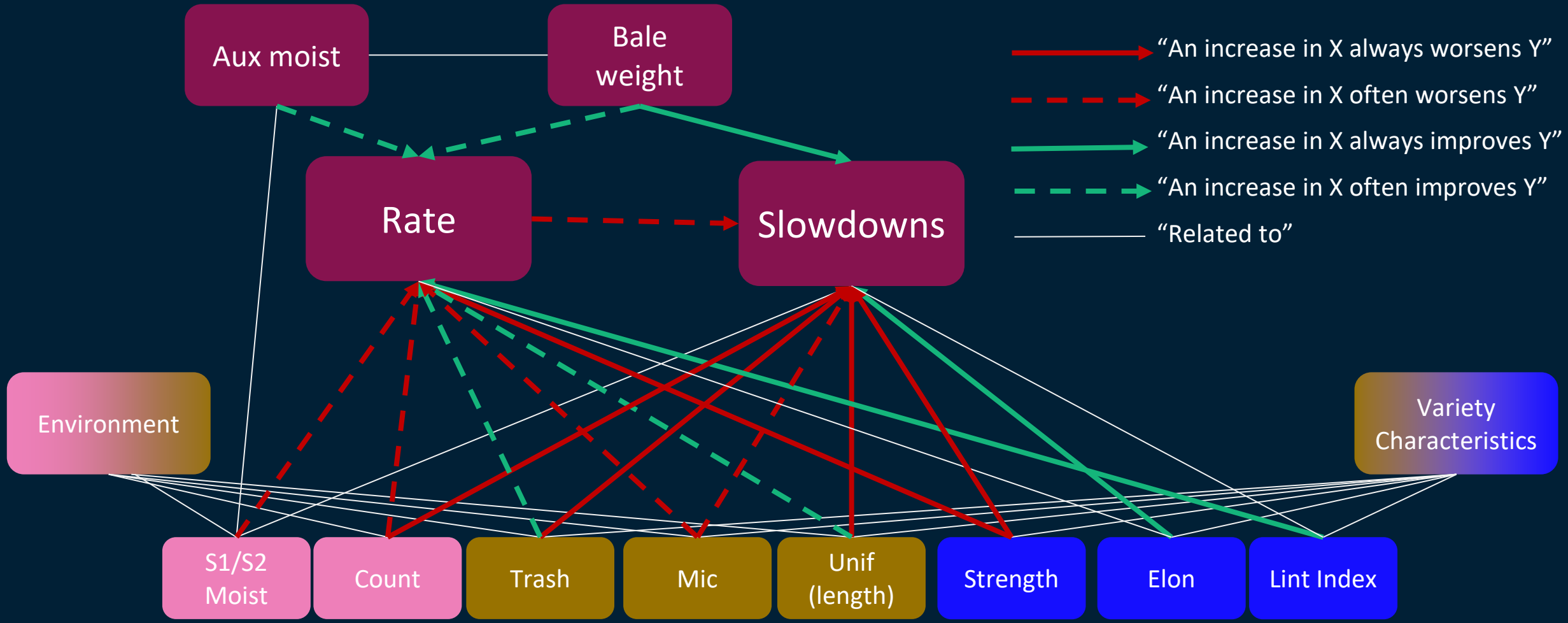
Data-Driven Cotton Industry of the Future

- Management decisions driven by data
  - Data collected with much greater precision- temporally, spatially
  - Precision agriculture, precision ginning, precision textile manufacturing
- Increasing levels of automation
  - Including data analytics
- Increased data sharing from “dirt to shirt”
  - Traceability
  - Data has value!

Capturing More Value From Data at the Gin

- Collaborative project with Cotton Incorporated, SAS, researchers, gin managers
- Used data from two gins over multiple seasons to model ginning rate
  - Data from over 500,000 bales will be used in 2022
- SAS used machine learning to develop model
  - “Big data” from the gin
- Much of variability can be explained by knowledge of farm, field, cultivar, and moisture content

Outcome

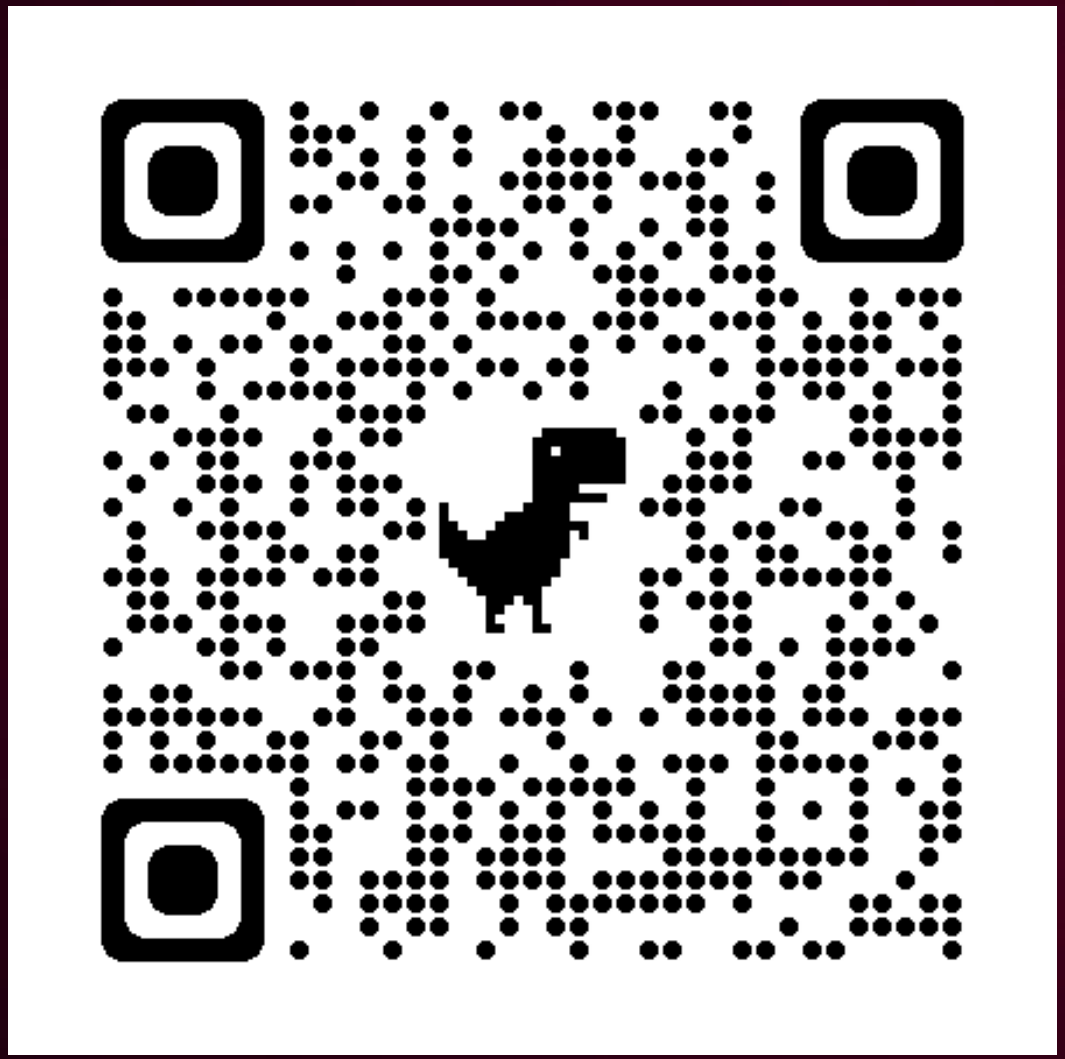

Aux moist
Bale weight
Rate
Slowdowns
Environment
Variety Characteristics
S1/S2 Moist
Count
Trash
Mic
Unif (length)
Strength
Elon
Lint Index
"An increase in X always worsens Y"
"An increase in X often worsens Y"
"An increase in X always improves Y"
"An increase in X often improves Y"
"Related to"

Summary

- RFID-tagged modules facilitate data sharing along the supply chain
  - Connected data from field to bale
- Other important data can be associated with a module's RFID number
  - Demonstrated use of images, moisture content
  - Potentially farm production data, quality sensors on harvesters
- RFID technology has value in inventory management and logistics optimization
- Greater use of data should generate value throughout supply chain

Acknowledgments

- Financial support and leadership of Cotton Incorporated
- Collaborators
- Cooperating farmers and ginners
- Students



Scan the code for links to references.

Thank you!

robert.hardin@ag.tamu.edu