REAL-TIME VARIABLE RATE TECHNOLOGIES (VRT)

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OUTLINE

- VRT Concept and Architecture
- VRT Applications and Results
  - Liquid Manure
  - Herbicide
  - Forages Harvesting (Mowing)
  - Planting

PRECISION AGRICULTURE

"… to optimize crop production and reduce the environmental footprint by using new digital technologies."

- Gebbers, R. and V.I. Adamchuk

GLOBAL NAVIGATION SATELLITE SYSTEM BASED MACHINERY GUIDANCE

VARIABLE RATE TECHNOLOGIES

Adoption limited?

↓

Lack of robust decision making principles

+

High cost

=

Research

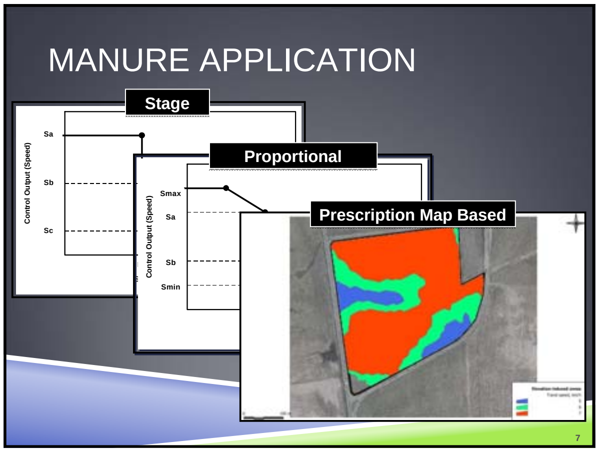
TECHNOLOGY ARCHITECTURE

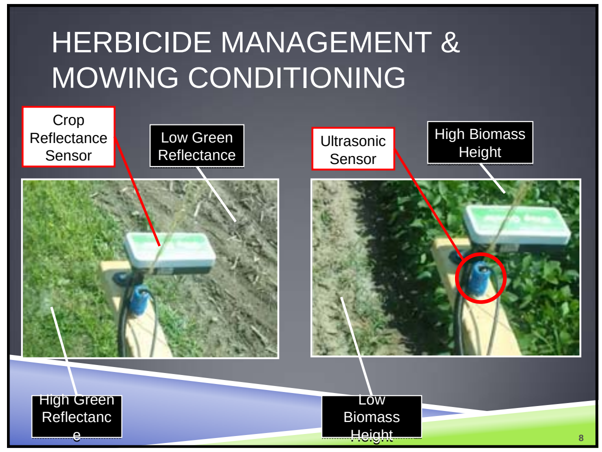
Internal Sensor
External Sensor
Prescription Map

→ Controller Algorithm

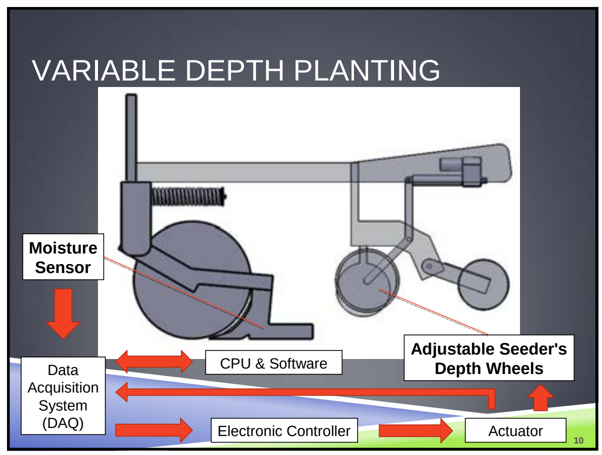
Relation?

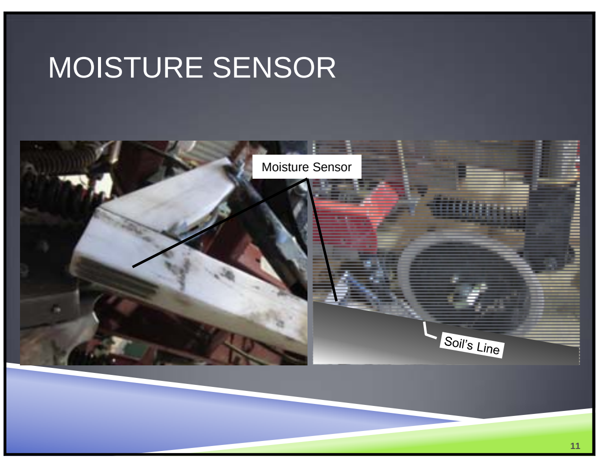
Tractor | Implement

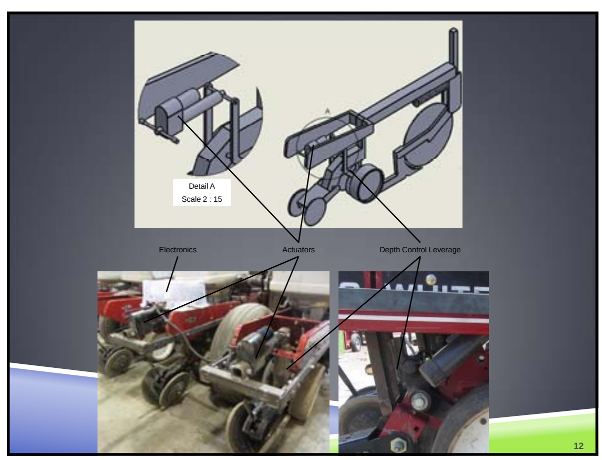

MANURE APPLICATION
Stage
Proportional
Prescription Map Based
Control Output (Speed)
Sa
Sb
Sc
Smax
Smin
7

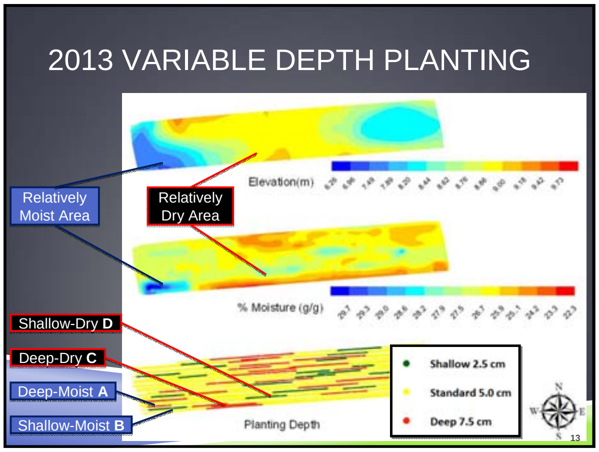

HERBICIDE MANAGEMENT & MOWING CONDITIONING
Crop Reflectance Sensor
Low Green Reflectance
Ultrasonic Sensor
High Biomass Height
High Green Reflectanc e
Low Biomass Height
8

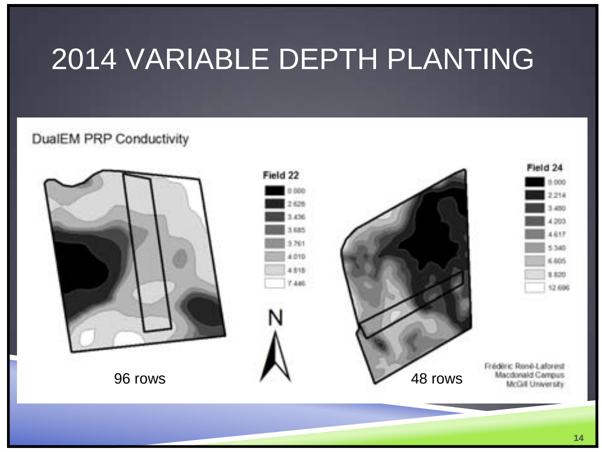

Sensors Platform
Calibration point
50 x 50 cm
9

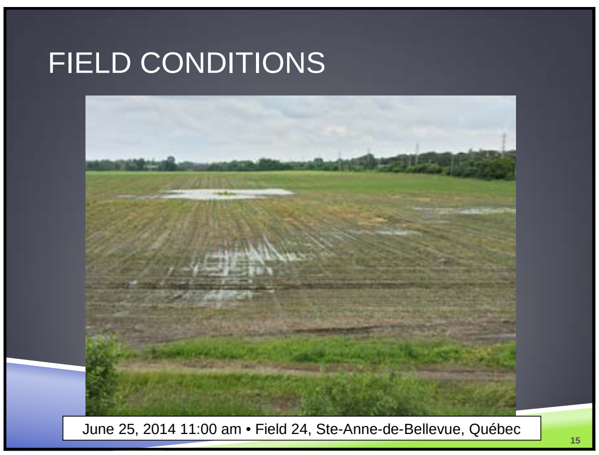

VARIABLE DEPTH PLANTING
Moisture Sensor
Data Acquisition System (DAQ)
CPU & Software
Adjustable Seeder's Depth Wheels
Electronic Controller
Actuator
10

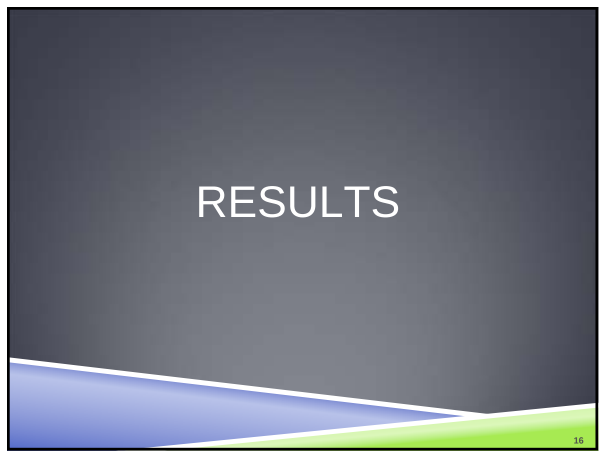

MOISTURE SENSOR
Moisture Sensor
Soil's Line
11

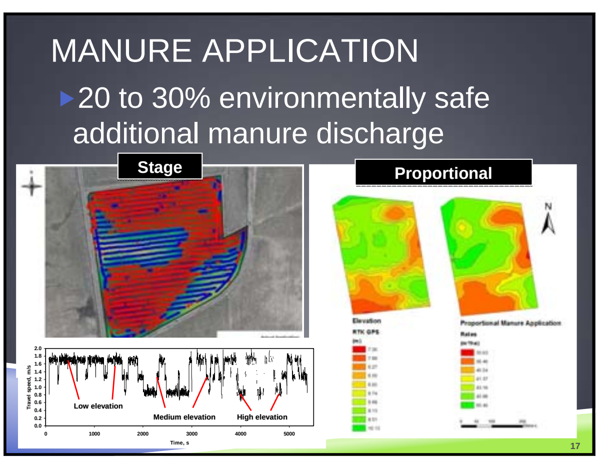

Detail A
Scale 2 : 15
Electronics
Actuators
Depth Control Leverage
12

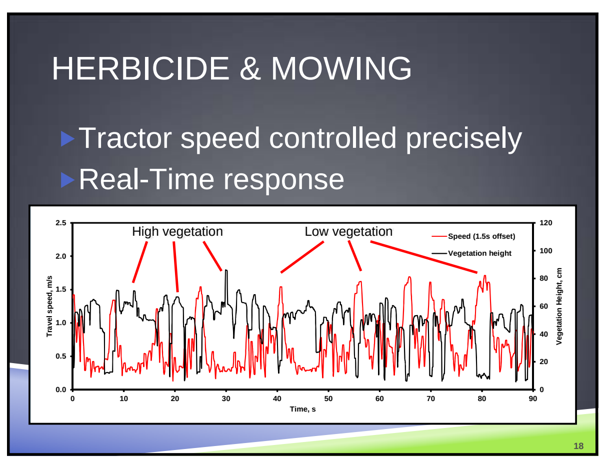

2013 VARIABLE DEPTH PLANTING
Elevation(m)
Relatively Moist Area
Relatively Dry Area
% Moisture (g/g)
Shallow-Dry D
Deep-Dry C
Deep-Moist A
Shallow-Moist B
Shallow 2.5 cm
Standard 5.0 cm
Deep 7.5 cm
Planting Depth
13


2014 VARIABLE DEPTH PLANTING
DualEM PRP Conductivity
Field 22
Field 24
N
96 rows
48 rows
Frédéric René-Laforest
Macdonald Campus
McGill University
14


FIELD CONDITIONS
June 25, 2014 11:00 am • Field 24, Ste-Anne-de-Bellevue, Québec
15


RESULTS
16


MANURE APPLICATION
▸20 to 30% environmentally safe additional manure discharge
Stage
Proportional
Low elevation
Medium elevation
High elevation
Time, s
17


HERBICIDE & MOWING
▸Tractor speed controlled precisely
▸Real-Time response
High vegetation
Low vegetation
Speed (1.5s offset)
Vegetation height
Travel speed, m/s
Vegetation Height, cm
Time, s
18

VARIABLE DEPTH PLANTING
2013 EXPERIMENT

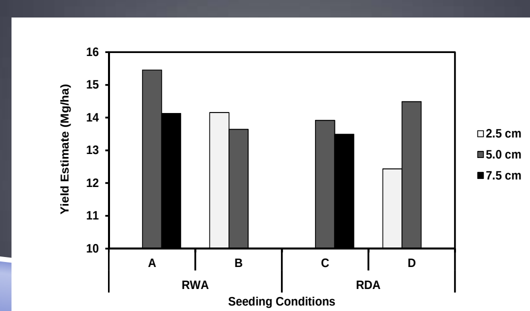
PLANTING: EMERGENCE

PLANTING: ROOTING SYSTEM

RESULTS: ROOTING SYSTEM

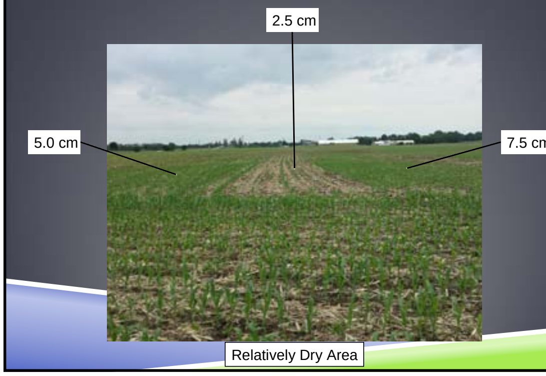
RESULTS: COBS

RESULTS: YIELD

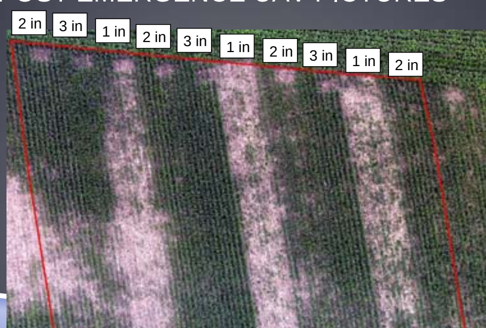


VARIABLE DEPTH PLANTING 2014 EXPERIMENT

PRELIMINARY RESULTS



POST EMERGENCE UAV PICTURES



CONCLUSION

GNSS (GPS)
+
Prescription Map
+
Crop Reflectance
+
Moisture Sensor
+
Ultrasonic Sensor
+
………….

Robust Decision Making Controller (Algorithm)

QUESTIONS?

Mapping soil water content using an on-the-go capacitive moisture sensor

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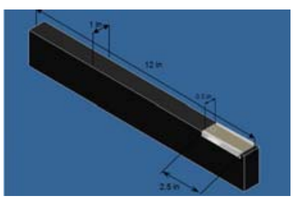
Ste-Anne-de-Bellevue, Quebec

Charles R. Hempleman
Retrokool Inc., Berkeley, California

Background and Objective

- Monitoring agricultural field soil moisture has many useful applications.
- Currently, accurate moisture sensors are point based and cannot provide true picture of field's moisture heterogeneity.
- Possible uses of an on-the go moisture sensor: variable depth planting, after-harvest soil water content mapping.
- Objective was to build capacitance based sensor that is capable of collection soil moisture data in real-time.

Sensor Design



- Two (2) stainless steel electrodes connected to proprietary electronic circuit (Retrokool, Inc) via coaxial cable.
- Teflon casing.
- Electrodes cut at angle for proper contact with soil.

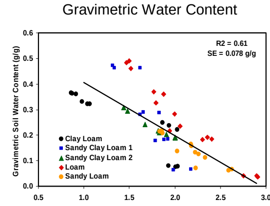
Sensor Design

Lab Calibration

- 5 soils tested
  - Clay loam, sandy clay loam (2 samples), loam, sandy loam.
- Soil moisture was measured via sensor and oven-drying method.
- Sensor was suspended in air before being depressed for each replication to measure voltage drop (Vair to Vsoil).
- Voltage drop matched to oven-dried moisture level.

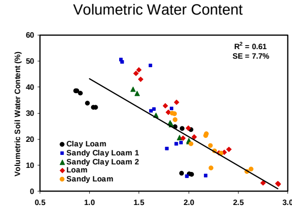
Lab Calibration

Gravimetric Water Content



$$w = 0.61 - 0.21\log(V_{air} - V_{soil})$$

Volumetric Water Content



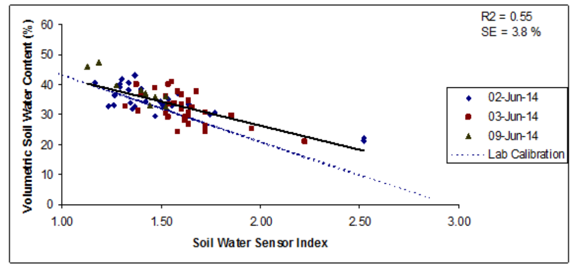
$$\theta = 65.4 - 22.3\log(V_{air} - V_{soil})$$

Field Testing

- Sensor was attached to planter via coulter disc and pulled behind tractor during seeding.
- Point-based measurements using time domain reflectometer (TDR) probe were taken after sensor had been pulled through soil.
- Voltage drop matched to TDR measurements using GPS points.

Planter **Moisture Sensor**

Field Testing



Future Plans

- Improve robustness of sensor.
- More laboratory calibrations to examine more closely effect of soil type (i.e. clay) on results and determine if different soil types require different calibration equations.
- More field tests.

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2014 ASABE/CSBE Annual International Meeting
Montréal, Québec

Mapping forage crop biomass with an integrated proximal sensing system

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McGill University

Gustavo Portz
University of São Paulo

October 24, 2014

Background

- Site specific crop management of agricultural fields
  - responds to localized plant needs with optimized amount of chemical and fertilizer application
  - increase in farming efficiency
  - reduces the negative environmental impact
- Yield mapping has become a popular practice for grain crops, forage crop production lags behind in term of collecting yield-related information

Objective

- Creating an on-the-go integrated proximal sensing system for mapping forage crop biomass
  - Spectral sensors
  - Ultrasonic Proximity Sensors
  - IR Temperature Sensors
  - GPS

Sensors

Spectrum:
Holland Scientific
•Crop Circle - ACS-430

Measured output	Wavelength / Formula
Red-Edge (RE)	670 nm
Red	730 nm
Near Infrared (NIR)	780 nm
Normalized Difference VI (NDVI)	$\frac{\rho_{NIR}-\rho_R}{\rho_{NIR}+\rho_R}$
Normalized Difference Red-Edge (NDRE)	$\frac{\rho_{NIR}-\rho_{RE}}{\rho_{NIR}+\rho_{RE}}$

Sensors

IR Thermometer
Process Sensors Co.
- PCS-SSS

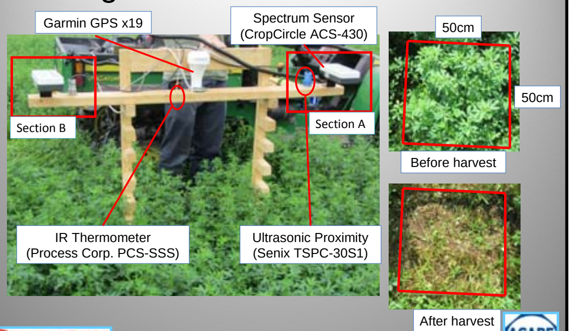
Ultrasonic Proximity Sensor (UPS)
Senix Co.
- TSPC-30S1
- Operational distance 10.2cm to 2m

Global Positioning System (GPS)
Garmin
- Model 19x

2013 SENSORS CALIBRATION

August 9th, 2013

Forage Yield Calibration Process



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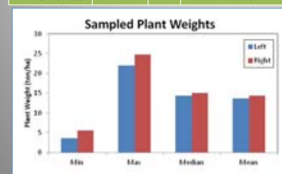
Experimental design

Sensor	Samples	Rep	Left side	Right Side
Ultrasonic Proximity	20	2	YES	YES
Crop Circle – Compensate	20	1	YES	NO
Crop Circle – Non-Compensate	20	1	NO	YES
IR Thermometer	20	1	Middle	



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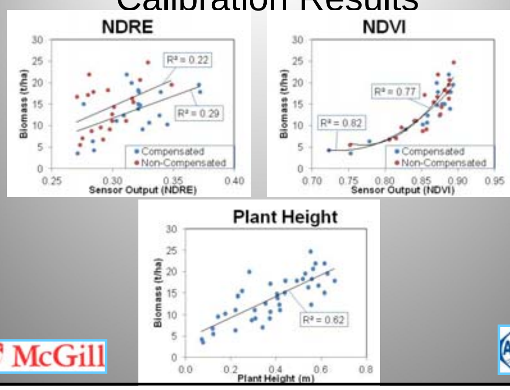
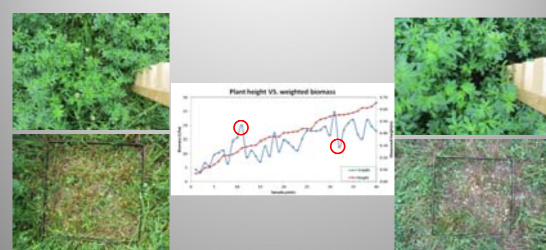
Calibration Results



McGill ASABE

Calibration Results



McGill ASABE

2013 - INTEGRATED SYSTEM FOR YIELD MONITORING

August 15th, 2013

McGill ASABE

Mechanical Design

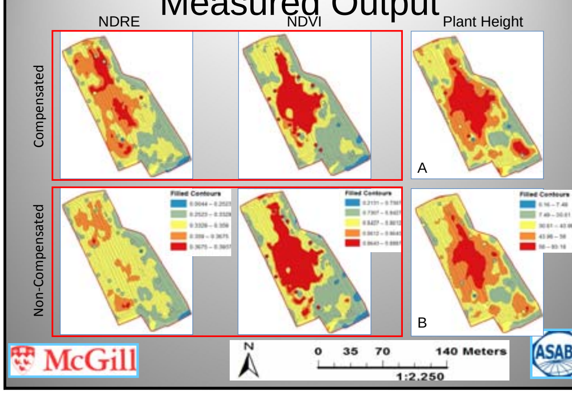
- New Holland
  - 2008 Discbine 1431 Disc Mower Conditioner

McGill ASABE

Mechanical Design

Data logging – Labview VI

Measured Output



In-situ Forage Yield Monitoring

Field ID	Area (ha)	Total Yield (Tonne) Based On Height	Yield (tonne/hectare)/ (US ton/acre)
55	3.06	59.21	19.35/7.71
64	4.63	61.59	13.30/5.30
66	4.50	66.76	14.84/5.45

2014

- Explore new analysis method
- Improve mechanical design

Thank you!