Autonomy Trends and Impact on Data Linking

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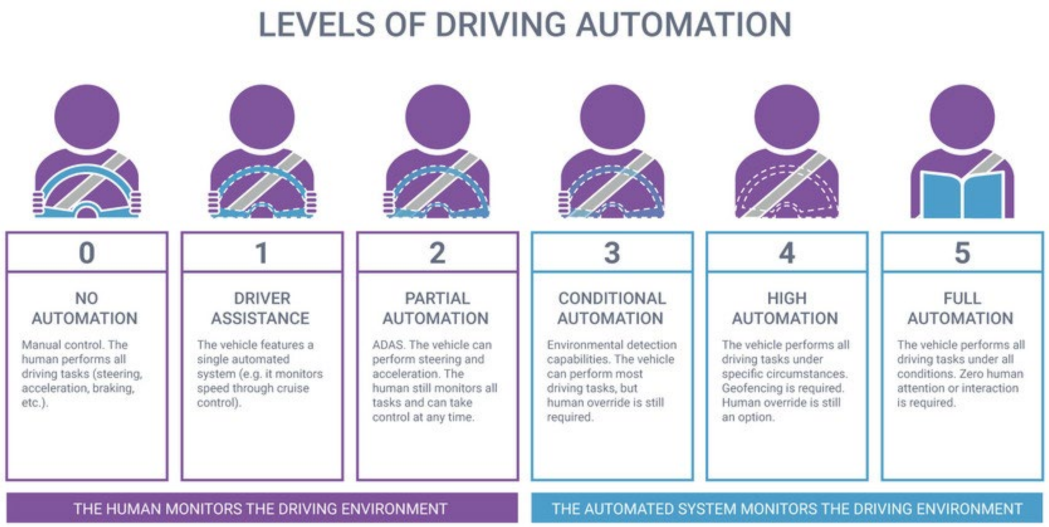
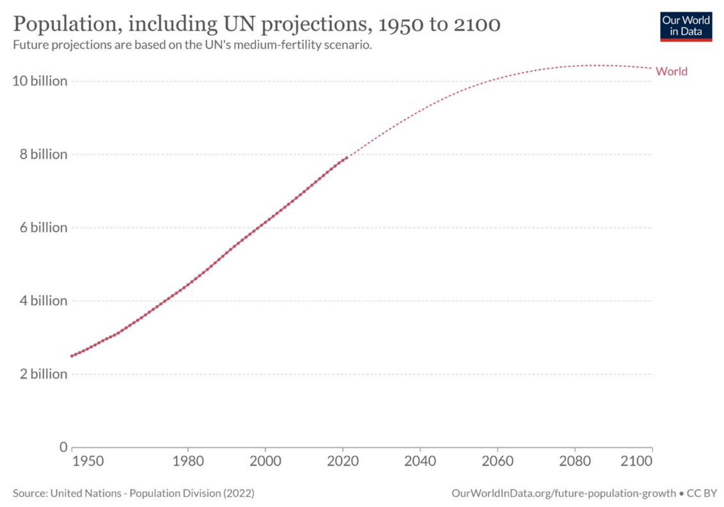
DEPARTMENT OF AGRICULTURAL AND BIOLOGICAL ENGINEERING

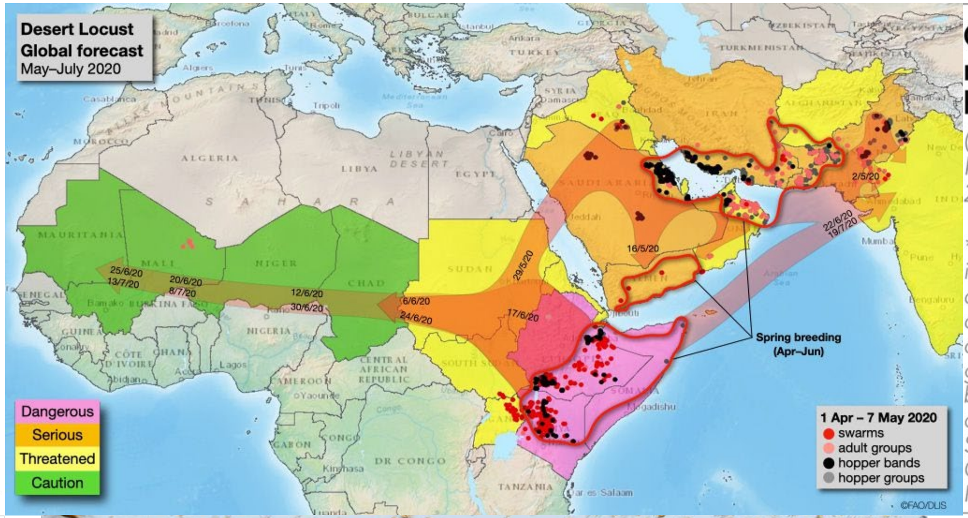
Agricultural Autonomy

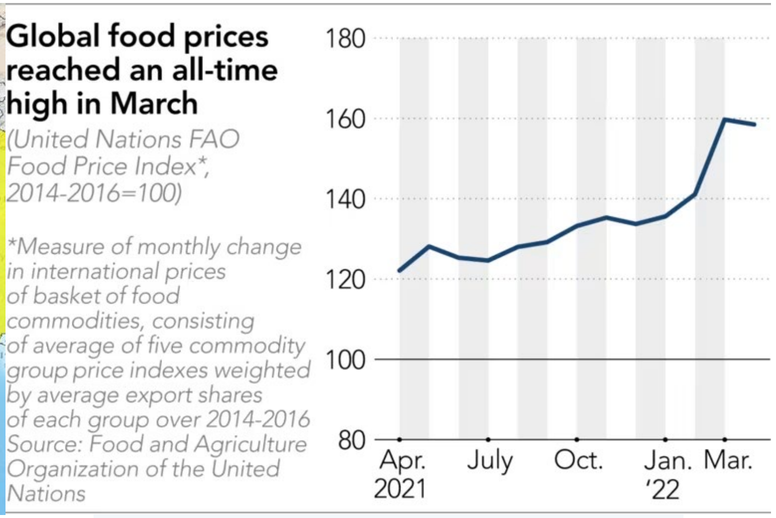
Agricultural Autonomy consists of agricultural machines and systems of machines that act independent of human control. It requires sensing, decision-making, and action-taking technologies. Examples are driverless tractors and robotic harvesters. Agricultural Autonomy also benefits from ‘big data,’ IoT, AI, broadband communications, cloud computing, edge computing, etc.

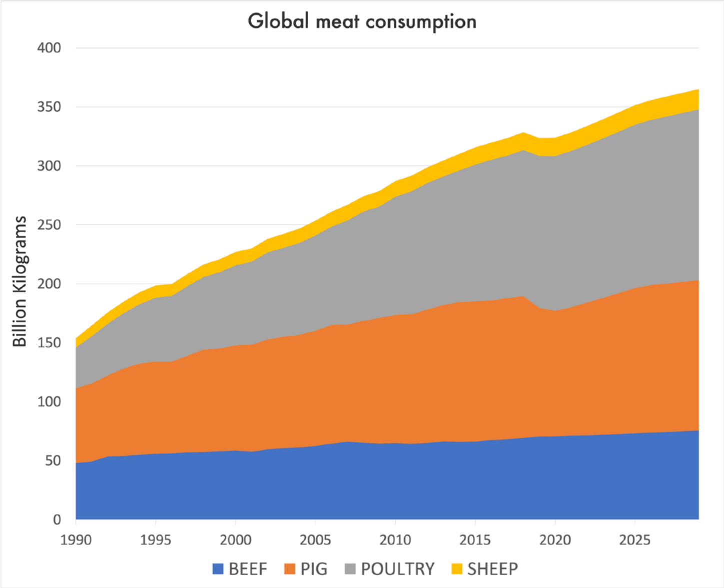


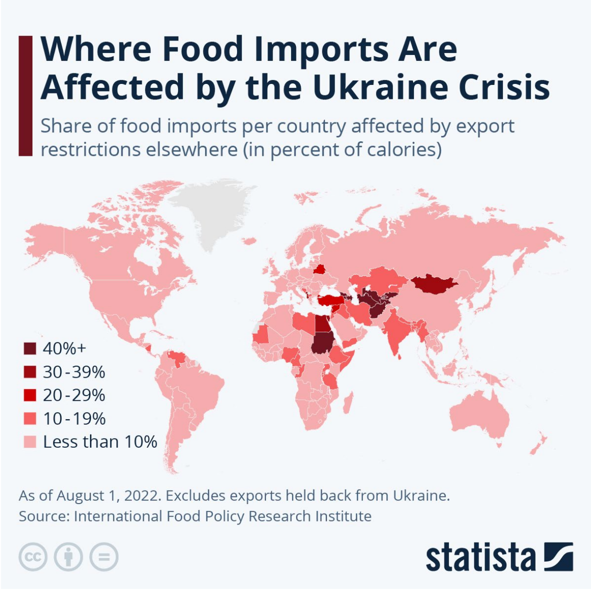
Higher yield and excess capacity











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Greater precision

4 Rs of Precision Ag

Applying **RIGHT** INPUTS (seed, water, fertilizer, crop protectants, labor, fuel, etc.)

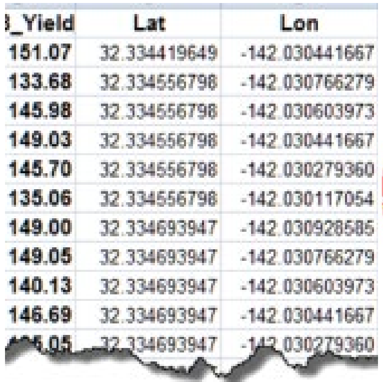
–At the **RIGHT** LOCATION

–In the **RIGHT** AMOUNT

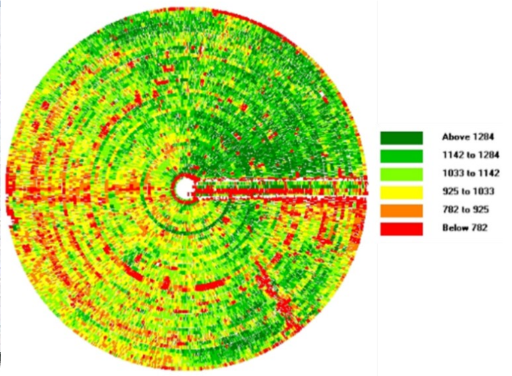
–At the **RIGHT** TIME

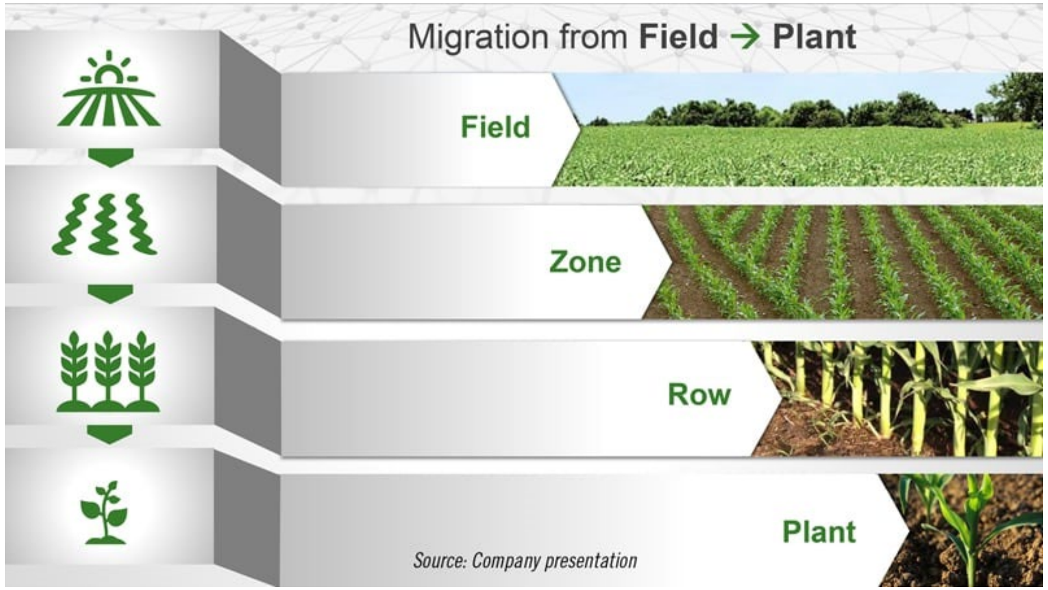
Requirements

- **data *about field conditions***
- **analysis**
- ***smart machines***



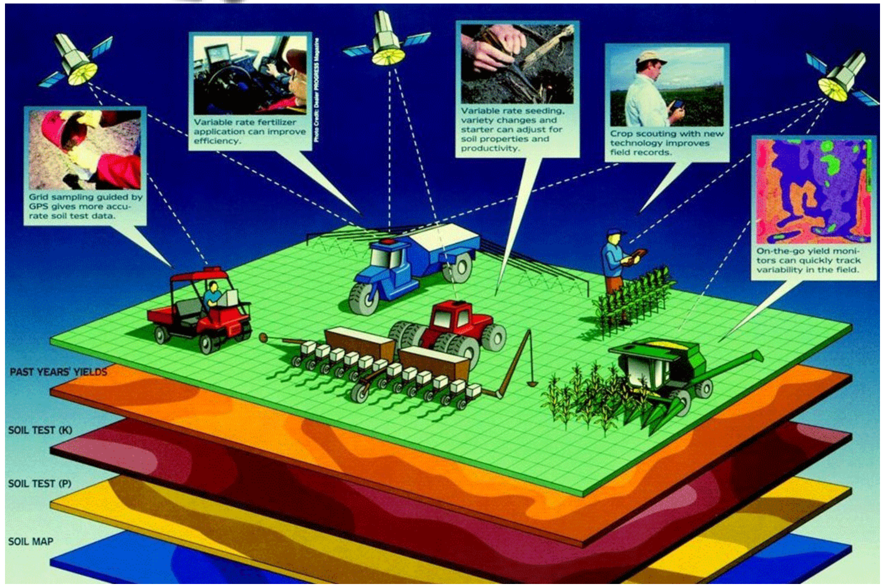
_Yield	Lat	Lon
151.07	32.334419649	-142.030441667
133.68	32.334556798	-142.030766279
145.98	32.334556798	-142.030603973
149.03	32.334556798	-142.030441667
145.70	32.334556798	-142.030279360
135.06	32.334556798	-142.030117054
149.00	32.334693947	-142.030928585
149.05	32.334693947	-142.030766279
140.13	32.334693947	-142.030603973
146.69	32.334693947	-142.030441667
[illegible]	32.334693947	[illegible]



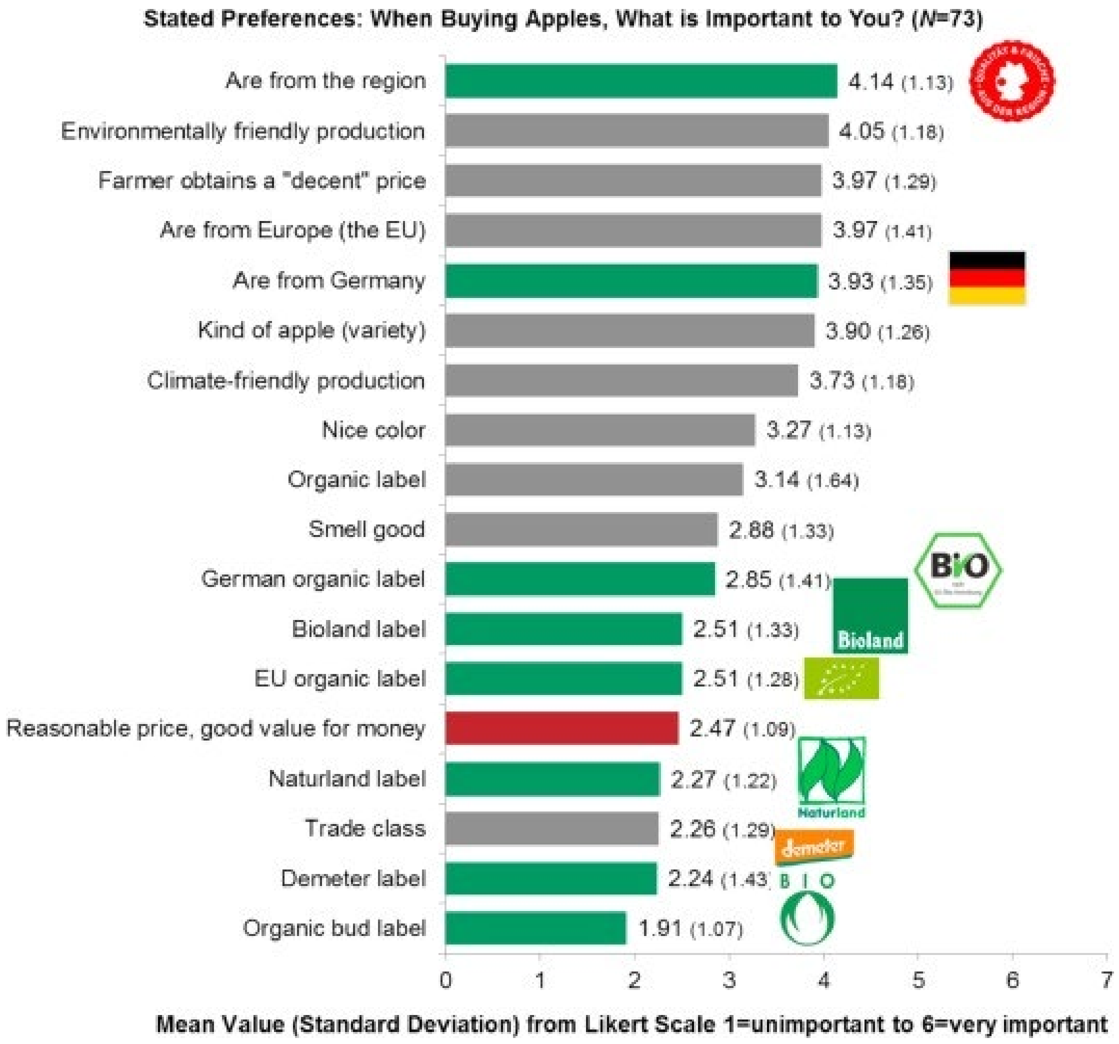


From field-scale

To plant-scale



Traceability



Traceability

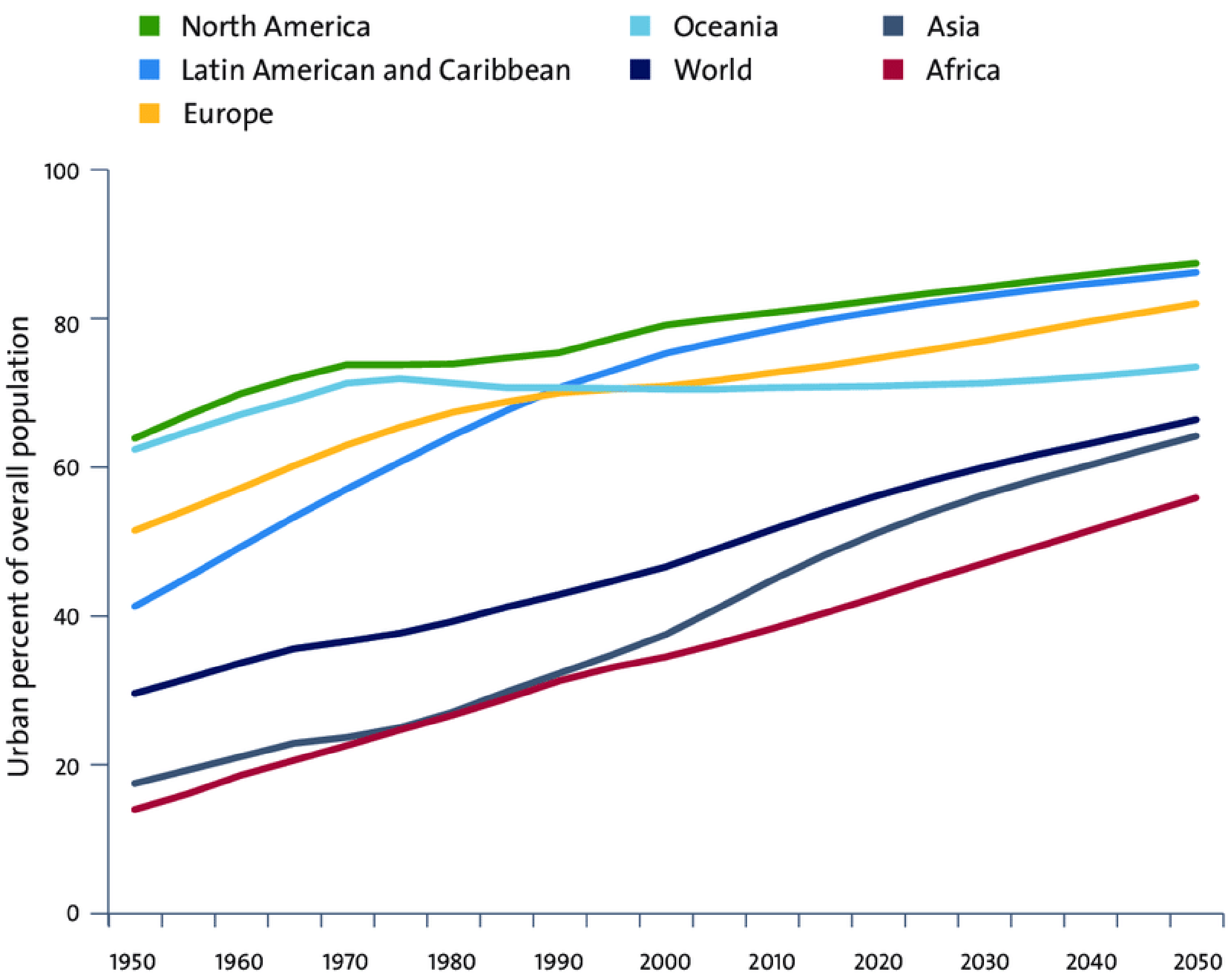
Field

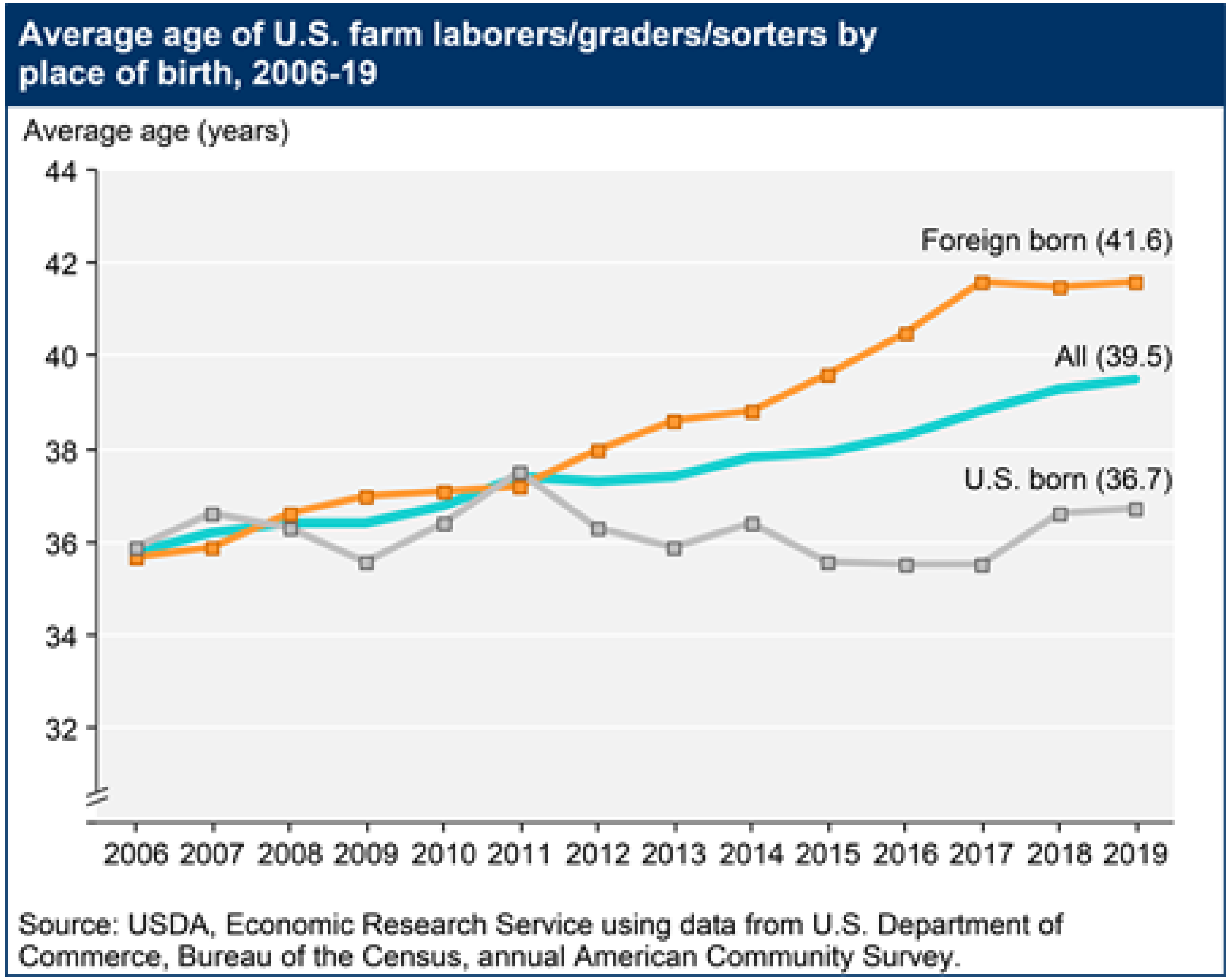
Inclusion rate:
1 tracer/1kg grain

Farm storage

Stored and dried

Labor


North America
Latin American and Caribbean
Europe
Oceania
World
Asia
Africa
Urban percent of overall population
100
80
60
40
20
0
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050


Average age of U.S. farm laborers/graders/sorters by place of birth, 2006-19
Average age (years)
44
42
40
38
36
34
32
Foreign born (41.6)
All (39.5)
U.S. born (36.7)
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Source: USDA, Economic Research Service using data from U.S. Department of Commerce, Bureau of the Census, annual American Community Survey.

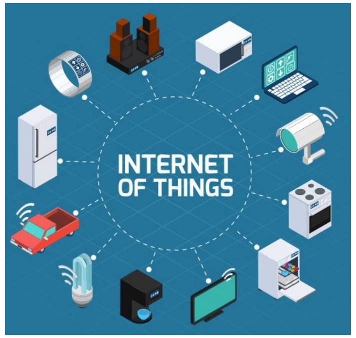
Trend toward reduced size

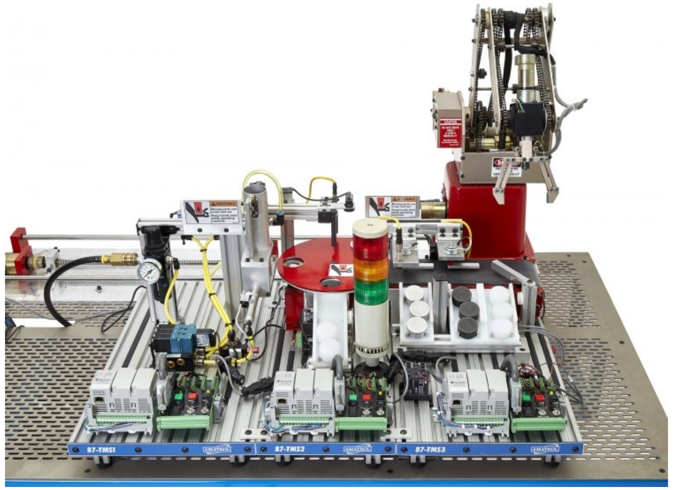
- "…future products will incorporate semi- and fully autonomous features that will eventually lead to partially or totally autonomous machinery."
- "There is a lot of evidence to support the argument that farm labor, OEM financial risk, and global infrastructure are driving the future of agriculture equipment development – which will see a reverse trend to smaller, more versatile, and more economical machinery."

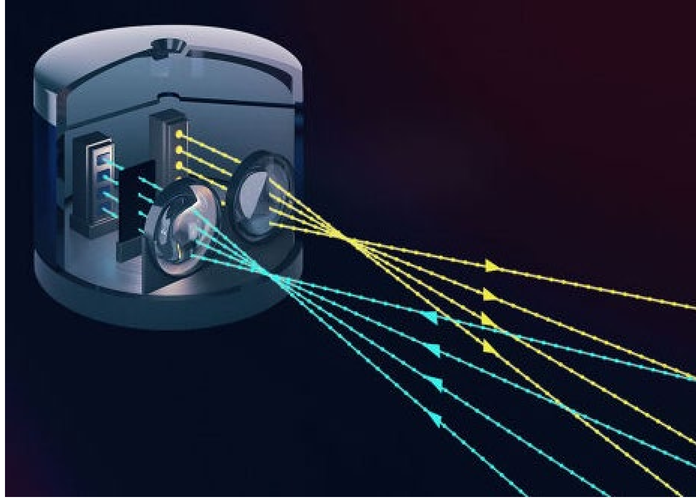
Maury Salz, Resource Nov./Dec. 2016.

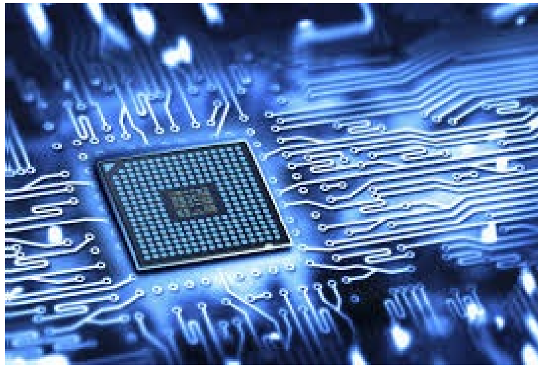
Enabling Technological Advances

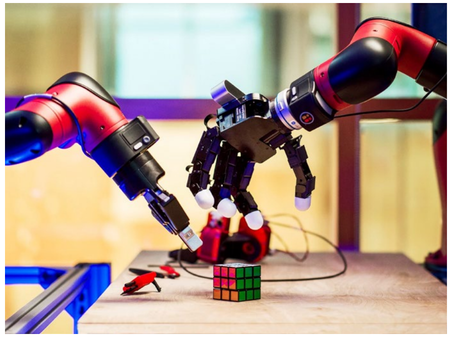
- Mechatronics
- Sensors
- Communications
- Computing
- IoT
- Analytics
- Robotics

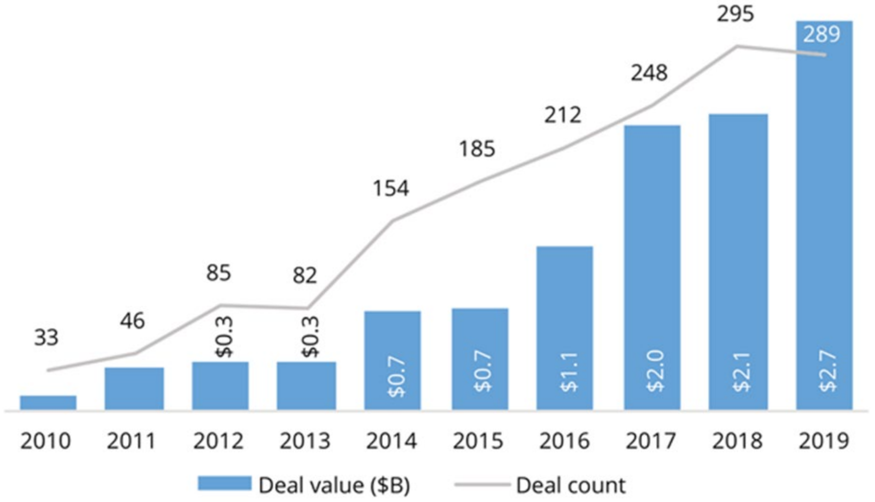








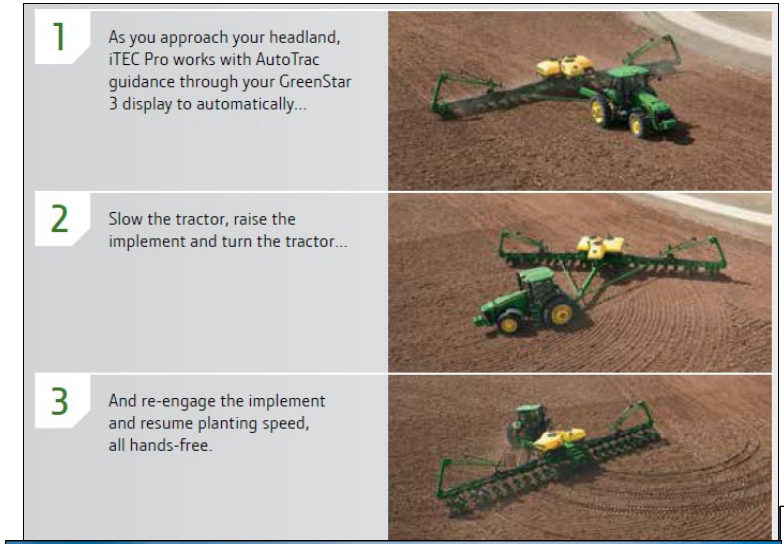


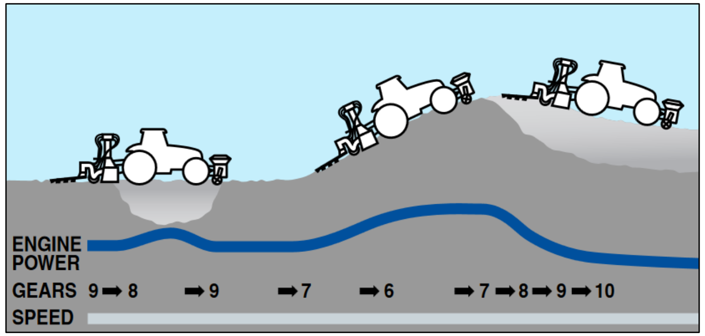


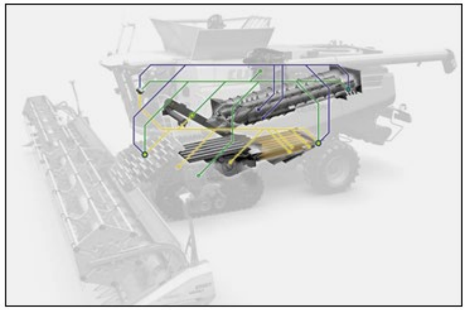
Source: PitchBook | **Geography:** Global

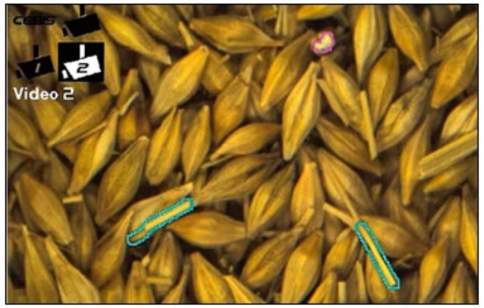
“Stacks” of Autonomous Technologies Already on the Market

- Automatic Implement Guidance
- Automatic Headland Sequence and Turn Management
- Sensing for Perception
- Sensing for Variable-Rate Technologies
- Optimization of Machine Operation
- Machinery Coordination
- Machinery Communication









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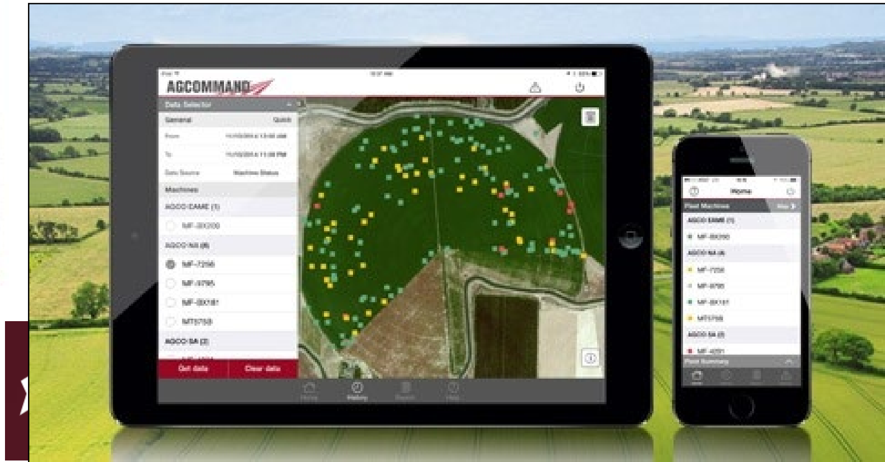


Latest developments

- Autonomous navigation

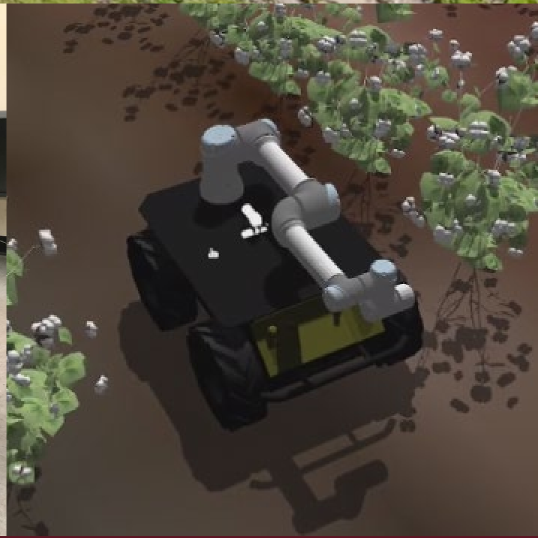
- Autonomous logistics

- Autonomous orchard spraying

- Autonomous tillage

The Agricultural Autonomy Institute (AAI) at Mississippi State University

Alex Thomasson, Director



AAI History

- Mississippi State University (1862 Land Grant)
  - College of Agriculture and Life Sciences (9 departments)
  - College of Engineering (8 departments)
  - Center for Advanced Vehicular Systems (CAVS)
  - Geosystems Research Institute (GRI)
  - Raspet Flight Research Laboratory (RFRL)
  - Etc.
- Agricultural Autonomy Working Group
  - 3 years
  - 40 members
  - Monthly discussion of collaboration and opportunities
- Agricultural Autonomy Institute
  - Grant from charitable foundation in Mississippi in 2022
  - Approval as university institute in 2023
  - Hiring of Associate Director and Program Manager
  - Grand Opening, October 26

AAI Organization

MISSISSIPPI STATE UNIVERSITY
DIVISION OF AGRICULTURE, FORESTRY, AND VETERINARY MEDICINE

MISSISSIPPI STATE UNIVERSITY
OFFICE OF RESEARCH AND ECONOMIC DEVELOPMENT

MISSISSIPPI STATE UNIVERSITY
COLLEGE OF AGRICULTURE AND LIFE SCIENCES

MISSISSIPPI STATE UNIVERSITY
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JAMES WORTH BAGLEY COLLEGE OF ENGINEERING

MISSISSIPPI STATE UNIVERSITY
MS AGRICULTURAL AND FORESTRY EXPERIMENT STATION

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EXTENSION

AAI Scope

- Types of Machines
  - Conventional agricultural equipment (tractors, combines, etc.)
  - Unconventional agricultural equipment (advanced sprayers, small robots, logistics systems, etc.)
  - Drones
  - Teams of airborne and ground-based robots
- Applications
  - Production
  - Processing
  - Research
- Technologies
  - Sensors
  - AI
  - Robotics
  - Simulation
  - Wireless communications
  - Etc.

AAI Focus

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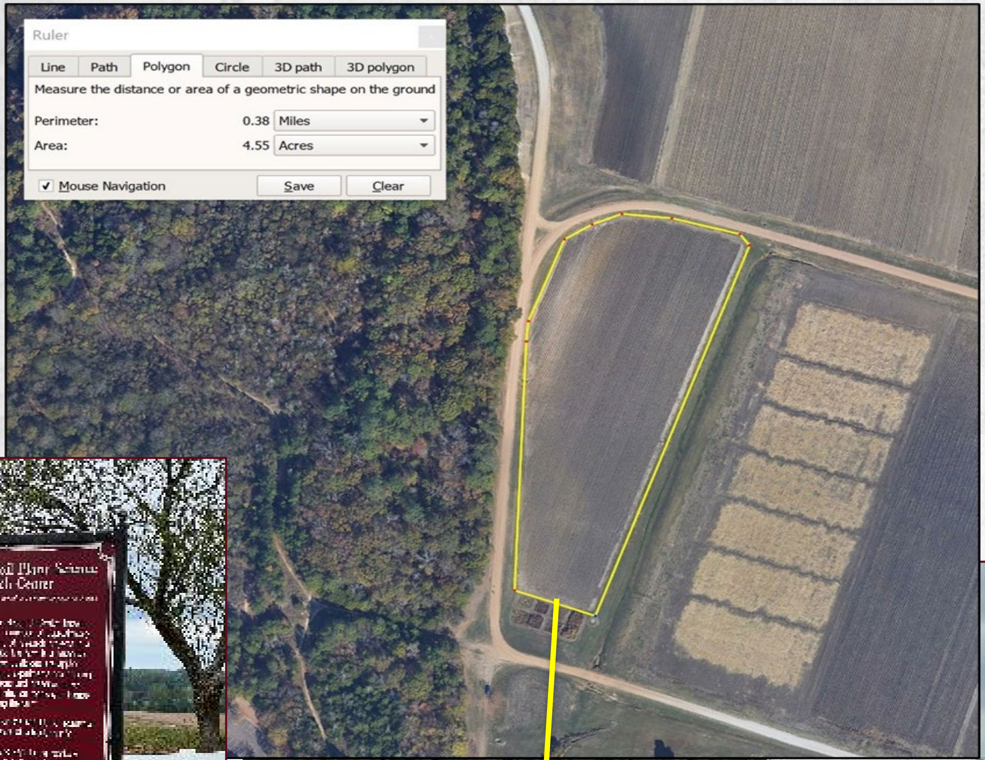
- Economic Development
  - Research and IP development
    - Internal research & spinoffs
    - Corporate-funded research
      - Innovations in technology
      - Testing and evaluation
  - Attracting industry
    - Research
    - Manufacturing
    - Distribution
  - Workforce development
    - University-level courses of study
      - B.S.
      - M.S.
      - Ph.D.
    - Community College collaborations




AAI Facilities

- Offices in MSU's Pace Seed Technology Building
- 4,800 sq. ft. Autonomy Lab with offices for staff and students
- Using university funds for lab renovation
- Renovated Autonomy Lab will host AAI Grand Opening event on October 26th, 2023.

AAI Facilities



- Autonomous Acres proving ground
  - Located at MSU's R.R. Foil Plant Science Research Center ("North Farm")
  - Immediately north of MSU's main campus in Starkville, MS
  - Immediately adjacent to CAVS's 80-acre proving ground off-road autonomy in forested terrain
  - University is investing in permanent infrastructure including solar-powered autonomous charging stations.
- Together with CAVS Proving Ground serves to provide comprehensive site for autonomous vehicle testing, evaluation, and demonstration.

AAI Activities

- Collaborative discussions
  - Agricultural equipment manufacturers
  - Drone manufacturers
  - Processing facilities
  - Commodity organizations
  - Government entities
- Proposal writing
- Progressing ongoing projects
  - Testing OEM autonomous systems
  - Autonomous cotton harvesting
  - Autonomous berry harvesting
  - Collaborative air and ground robotics
  - Etc.

https://twitter.com/Chudson_PhD/status/1636529533057638401?s=20

Autonomy and data linking

- Autonomy and Precision Agriculture
  - Similarities
    - Data
    - Analytics
    - Smart machines
  - Differences
    - Real-time use of data, analytics, smart machines
    - Edge computing
    - Teams of machines
    - “Big Iron” to “Small Iron”
    - Etc.

ASABE Standard S611:
Collecting, Processing, and Visualizing Geographic Harvest Data

1. Purpose and Scope
2. Background
3. Normative References
4. Definitions
5. Data Collection
6. Data Processing
7. Data Visualization

American Society of Agricultural and Biological Engineers

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News Release

FOR IMMEDIATE RELEASE
August 21, 2023

ASABE DEVELOPS STANDARD ON MAPPING YIELD AND ASSOCIATED DATA

ST JOSEPH, MICHIGAN— The American Society of Agricultural and Biological Engineers developed a standard for the collection, processing, and visualization of data files containing geographic harvest data. Such data include yield, moisture content, and other spatially variable properties, such as grain protein content, and cotton-fiber maturity.

This new standard, ANSI/ASABE S611 JUN2023, Collecting, Processing, and Visualizing Geographic Harvest Data, complements an international standard ISO 11783, Tractors and machinery for agriculture and forestry—Serial control and communications data network, by providing context for how geographic harvest data is used in practice. The new ASABE standard will also benefit systems that do not conform to the ISO document, maximizing interoperability with farm management information systems (FMIS).

This new standard does not prescribe the manner in which field equipment records these data. Rather, it highlights the importance of accurately preserving the meaning of the data so that it can be processed into a form that is fit for use within FMIS software and easily serializable for data exchange.

ASABE members with standards access and those with site-license privileges can access the full-text via electronic download on the ASABE online Technical Library at elibrary.asabe.org/. Others can obtain a download for a fee directly from the library or by contacting ASABE headquarters at OrderStandard@asabe.org.

The American Society of Agricultural and Biological Engineers is in the process of developing a standard for the collection, processing, and visualization of data files containing geographic harvest data. Such data include yield, moisture content, and other spatially variable properties, such as grain protein content, and cotton-fiber maturity.

This new standard will complement ISO 11783 by providing context for how geographic harvest data is used in practice. Non-ISO systems will also benefit from this standard, in maximizing interoperability with farm management information systems (FMIS). This standard is

– more –

not meant to prescribe the manner in which field equipment records these data. Rather, it is intended to highlight the importance of accurately preserving the meaning of the data so that it can be processed into a form that is fit for use within FMIS software and easily serializable for data exchange.

ASABE Standard S611:
Collecting, Processing, and Visualizing Geographic Harvest Data

1. Purpose and Scope

a. Purpose

1) Improving collection, processing, visualization.
2) Complementing ISO 11783, but also benefitting non-ISO-11783 systems.
3) Non-prescriptive.

b. Scope

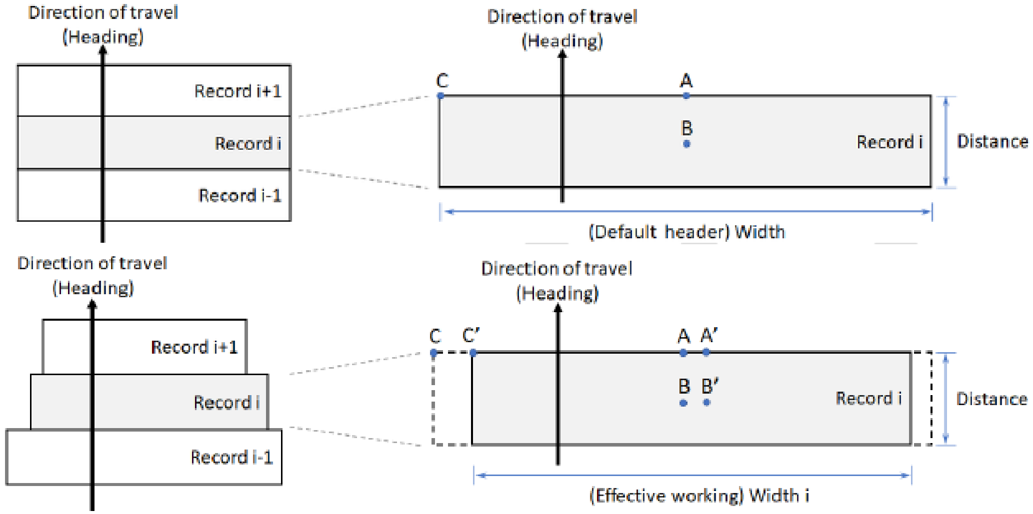
a. Collection, processing, and visualization of geographical harvest data collected from harvester during harvest.
b. Simplification of harvest record-keeping.
c. Data files collected with yield monitors and other sensors on harvesting machines.
d. Metadata.
e. Maximizing consistency and clarity.
f. Numeric and non-numeric data.
g. Quality of data assessed by realistically available data elements that convey value of data quality measures.

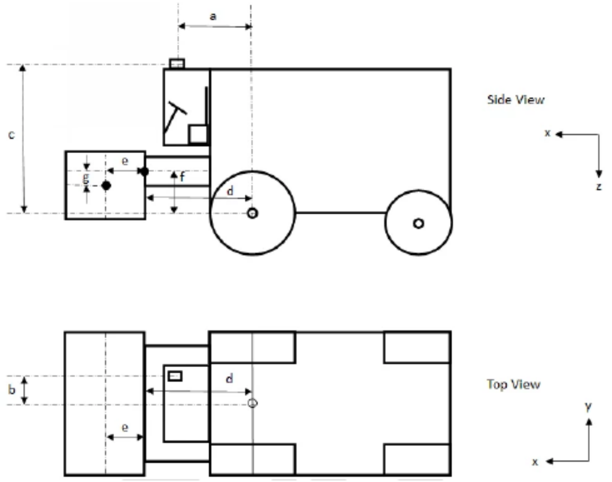
ASABE Standard S611:
Collecting, Processing, and Visualizing Geographic Harvest Data

2. Background
   a. Data are collected with sensors which are affected by various error sources.
   b. Data are often filtered, and this should be done after data have been collected.
   c. Raw sensor measurements should be stored to the extent possible, but provenance information should also be maintained.
   d. Mass or volume is used as the yield estimate, and mass of data points should be maintained.
   e. Transport lag must be considered.
   f. Content, format, and units of measure should be unified.
   g. Coding schemes for data visualization should provide uniformity and flexibility.

ASABE Standard S611:
Collecting, Processing, and Visualizing Geographic Harvest Data

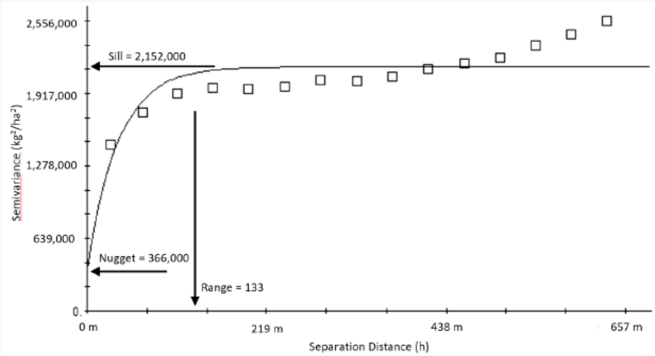
3. Normative References
    a. None.
4. Definitions.
    a. 102 definitions.
5. Data Collection
    a. Unique Identification: physical or data objects.
    b. Importance of Common Semantics: data type, unit of measure, spatial footprint, etc.
    c. Serialization/Datafile Format.
    d. File Header Information Content.
    e. Content for Harvest Data Records.
    f. Data Quality.

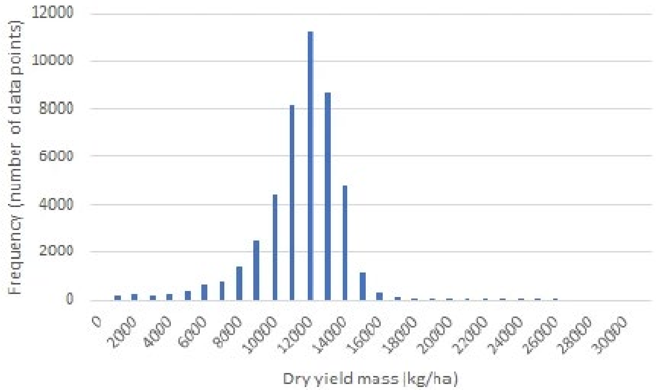


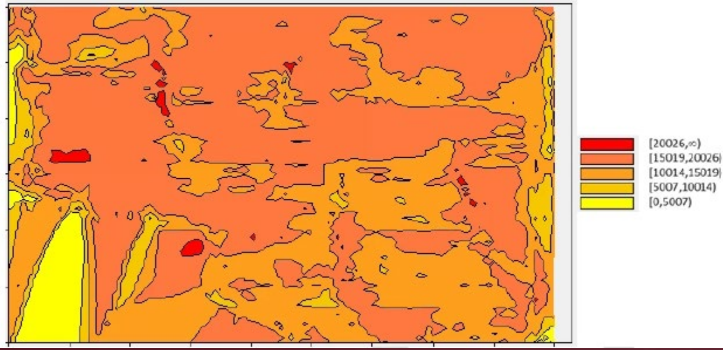


ASABE Standard S611:
Collecting, Processing, and Visualizing Geographic Harvest Data

6. Data Processing
    a. Data Filtering and Correction.
    b. Reporting of Filtering and Correction.
7. Data Visualization
    a) Summary Statistics: mean, standard dev., etc.
    b) Maps: swath elements or spatial interpolation.
    c) Coordinate System and Projection.
    d) Units of Measure.
    e) Required Map Annotations: compass, scale, etc.
    f) Types of Maps: vector, raster (interpolation).
    g) Legend Class: segmentation, no. of classes, types of breaks, statistical vs. absolute classification.
    h) Color Representation: visualization basics, color ramps, visual color impairment.







ASABE Standard S611:
Collecting, Processing, and Visualizing Geographic Harvest Data

- This standard is focused on Geographic Harvest Data
- What about Planter Data
- What about Application Data
  - Sprayer
  - Spreader
  - Etc.