

THE DIGITAL TRANSFORMATION OF ROW CROP AGRICULTURE

A Report to the Iowa AgState Group



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DESCRIPTION OF IOWA AGSTATE

HISTORY

The seeds of the Iowa AgState Group were planted in the spring of 1997 as representatives of farm and commodity organizations, agribusinesses, state government and Iowa State University began to talk about the need for a long-range, strategic plan for Iowa agriculture. A name designed to help the public understand the purpose of the group was chosen. Iowa AgState is an acronym for “Agricultural Strategic Thinkers Acting Together Effectively.”

The Vision and Mission Statements for Iowa AgState are:

VISION STATEMENT

- Empower Iowans to lead the world in responsibly-produced food and agricultural products to not only meet, but exceed, the demands of customers.

MISSION STATEMENT

- Dedicated to identifying challenges and opportunities in Iowa agriculture and recommending changes to help the entire state achieve the greatest possible benefit from Iowa's food, materials, and products industry.

MEMBER ORGANIZATIONS

- Agribusiness Association of Iowa
- Dairy Iowa
- Iowa Cattlemen's Association
- Iowa Corn Growers Association
- Iowa Corn Promotion Board
- Iowa Department of Agriculture and Land Stewardship
- Iowa Department of Economic Development
- Iowa Farm Bureau Federation
- Iowa Institute for Cooperatives
- Iowa Pork Producers Association
- Iowa Poultry Association
- Iowa Soybean Association
- Iowa State University College of Agriculture
- Iowa Turkey Federation
- Midwest Dairy Association

MOTIVATION FOR THIS PROJECT

- Iowa farmers have always been innovators in adopting new technology.
- During the last two decades, precision agriculture tools have been adopted by Iowa farmers with somewhat mixed success: –
 - *Some tools being highly regarded as very useful;*
 - *Other tools providing minimal value to farmers.*
- During 2013-14, concern began to grow within farmer organizations about the use and potential misuse of farm data.
- The promise of Big Data in agriculture was alluring, but there was also concern about the potential adoption challenges of the technology.
- Several farmer organizations in Iowa decided to ask AgState, as an umbrella organization for state-wide agriculture, to investigate the implications of Big Data for farmers.

THE TASK FORCE

The consulting team was guided by a six member Task Force that devoted major amounts of time and invaluable insights to the project. Task Force members included:

- Dr. Ed Anderson, Chair, Iowa Soybean Association
- Dr. Matt Darr, Iowa State University
- Kim Heckert, Iowa Institute for Cooperatives
- Brian Jones, Iowa Corn
- Dean Lemke, Agribusiness Association of Iowa
- Dave Miller, Iowa Farm Bureau Federation

This report is much stronger because of the many conversations, discussions, and debates with the Task Force.

BACKGROUND

The following are key terms and definitions that are used throughout this report:

- **Big Data:** Data whose scale, diversity, and complexity require new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it, e.g., weather data sets, satellite imagery of large farming areas, and aggregated farm level data from hundreds of thousands of acres.
- **Cloud Computing:** Computing in which large groups of remote servers are networked to allow centralized data storage and online access to computer services or resources.
- **Precision Agriculture:** The use of new tools that give farmers better operational control, e.g., auto-steer, yield monitors, variable rate applicators and planters. These are the hardware and software tools developed over the last two decades for key farming tasks.
- **Prescription Agriculture:** Detailed prescription of agronomic practices to maximize yield and profit per acre using computer algorithms, e.g., FieldScripts, Encirca, Answer Tech. These are sophisticated solutions which are largely based on computer models that are being introduced for row crop agriculture.
- **Enterprise Agriculture:** An integrated computer platform including planning, agronomy, human resource management, work orders, purchasing systems, risk management, inventory management, logistics control, machinery maintenance, marketing, and profit per acre. This is the development of an Enterprise Resource Planning system for the farm.
- **Digital Transformation:** This refers to the changes and challenges associated with digital technology application and integration into all aspects of agriculture. It is the shift from the physical to the digital.
- **Digital Agriculture:** A family of activities related to farming that includes Precision Agriculture, Prescription Agriculture, Enterprise Agriculture and depends on the collection, use, coordination, and analysis of data from a multiplicity of sources with the goal of optimizing productivity, profitability, and sustainability of farming operations, e.g., new decision making tools and new solutions. This is the comprehensive term used throughout this report that defines the complex process of digital transformation in farming and directly related sectors.
- **Advanced Farming:** The research activities that are designed to advance Digital Agriculture to achieve productivity and sustainability long-term, e.g., predictive phenomics. This concept is analogous to Advanced Manufacturing in the industrial sector.

The following abbreviations are used in this report:

- **APIs** – Application Programming Interface – In computer software an API allows software and hardware developed by different companies to “talk” to each other. This is a critical link to make the technology easier to use.
- **ATPs** – Agricultural Technology Providers – Companies that sell highly technical products and services to farmers.

- **CPC** – Crop Protection Chemicals.
- **Data Analytics** – The science of examining raw data with the purpose of drawing conclusions about that information.
- **Data Warehouse** – A central repository of integrated, current and historical, data from one or more disparate sources that is used for secure storage, reporting, and data analysis.
- **Embedded Knowledge** – Knowledge that is locked in products, processes, routines, structures, or systems that enables ease of use in practice. A good example is the iPhone.
- **FTE** – Full Time Equivalent employees – Two half-time employees equal 1 FTE.
- **IT** – Information Technology – The science of managing information with computers.
- **OADA** – Open Ag Data Alliance – An organization that seeks to encourage open sharing of data among ATPs.
- **PCAST** – President’s Council of Advisors on Science and Technology.
- **Smart Data** – Data that is of high quality when generated or has been corrected post-collection.
- **Technology Pull** – The farmers specify their problems and challenges which can be addressed by technical innovations.
- **Technology Push** – The developers of new products and services attempt to interest the market in the technical innovations that have been made.
- **UAVs** – Unmanned Aerial Vehicles or drones.

The following caveats regarding this report should be noted:

- This report does not endorse any specific company, product, or service. The examples provided are considered appropriate based on the information collected and the analysis of the consulting team.
- All information in this report is considered to be public information.
- The information in this report is based on research conducted through November 15, 2014.

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A. SUMMARY

The purpose of this project was:

To develop the most appropriate strategy and tactics for row crop farmers to utilize Agricultural Big Data to enhance the productivity, efficiency, and choices of American farmers while also protecting their farm data and intellectual property.

The approach used in this assignment was to:

- Conduct roughly 240 interviews with farmers, company executives, agronomists, industry association leaders, government officials, and academic experts.
- Analyze publicly available information on the internet and company websites.
- Lead four Focus Groups.
- Conduct an electronic survey of Iowa farmers.
- Conduct an electronic survey of Iowa agronomists.
- Synthesize all of the findings.
- Develop a farmer-centric strategy for the member organizations of Iowa AgState based on the findings and conclusions.

1. The New Digital Technology

The Digital Transformation of row crop agriculture is being driven by the rapid development of computer and communications technology in the U.S. economy, and the successful development of Precision Agriculture over the last 20 years. The wide adoption of yield monitors, GPS technologies and variable application equipment for seeds, fertilizer, and chemicals has enabled the development of computer generated prescriptions which have been introduced during the last few years. Farmers are experiencing a transition from simple mechanical based operations to complex computer based systems of systems.

A Technology Map in the form of a 6x3 matrix has been developed to: (1) categorize the very large array of products, services, and technologies that have been introduced and (2) identify how leading companies are positioned in the market. The major product and service categories are Precision Ag Equipment, Data Warehouse, Ag Retailer Software, Smart Data Deterministic Models, Probabilistic Models, and Farm Enterprise Systems. The major Technology Drivers are Data Generation and Capture, Cloud and Computer Processing Capacity, and Delivery Systems. The first two drivers move at the rapid pace of U.S. scientific and technology development and the third driver is based on the annual crop cycle.

The Gartner (a leading technology consulting firm) Quadrant methodology has been used to identify Leaders, Challengers, Visionaries, and Niche Players. The Leaders are John Deere & Co, DuPont Pioneer, Monsanto/The Climate Corp., SST Software, and WinField / Land O'Lakes.

Key conclusions are as follows:

- The Digital Transformation of row crop agriculture compares with past technological changes such as mechanization, hybrid seeds, and biotechnology.
- Data stewardship both in terms of privacy and security is a major challenge that will be prevalent for a long time.
- Digital Agriculture is still at an early stage of the adoption, and there is still time to shape both the technologies and the manner of adoption.
- Farmers are faced with a vast array of new products and services that do not have common standards so there is a major systems engineering problem to be solved.
- Decision-making in the future will be a complex mix of human and computer factors.

2. Company Positioning and Business Models

The business platforms that have been developed for each of the five leading companies identified above have been defined with an emphasis on the sources and structure used for technology development, the way the market is being accessed, and the major target customers. The level of investment is impressive with several companies reaching the \$1 Billion plus level, and there is a significant level of partnering and collaboration. Digital Agriculture is still at an early stage of development and is thus far less consolidated than the more mature segments of the agricultural sector.

At this early stage there is still a lot of flux in the business models with a variety of approaches being tested. A key challenge is that, with the exception of Precision Agriculture tools such as auto-steer, telematics, and row shut-offs, the value for many of the products and services have not yet been clearly established.

It will be necessary to define clear value for both tools and solutions before sustainable business models can be developed.

3. The Education Challenge

The Focus Groups, the farmer survey, and many interviews with individual farmers confirmed that the current state of Digital Agriculture technology is complex and confusing to the average farmer. The technology providers should improve their products and services so that farmers are offered solutions rather than tools.

The farmer survey indicated a very wide range of farmer attitudes toward the introduction of Digital Agriculture ranging from skepticism and fear to enthusiastic adoption. The Iowa AgState member organizations should assist their stakeholders to become informed about the technology so that farmers, ag retailers, other businesses, and policy makers can make informed decisions regarding their responses to the technology.

4. Policy Issues

A national initiative led by the American Farm Bureau Federation has focused on the appropriate guidelines for the ownership and use of data between farmers and the major technology companies. AgGateway is developing standards and guidelines to enhance the ease of data exchange among different service providers that serve farmers. The Open Agricultural Data Alliance is developing APIs that will facilitate the transfer of data to and from

companies under the control of farmers. All of these efforts are making a major contribution to the development of Digital Agriculture, and all of them serve the best interests of farmers.

To date the industry has not focused much attention on the legal uncertainty about data ownership and usage rights among farm operators, land owners, ag retailers, and other local service providers to farmers. These issues must also be resolved for Digital Agriculture to realize its full potential. One of the strategic initiatives cited below requires that the issue of ownership and use of data at the local level be resolved with clear, fair standards and guidelines.

5. Considerations for Strategy Development

The current status of Digital Agriculture can be summarized at a high level as follows:

- This technology will continue to improve rapidly.
- The farmers that adopt this technology will have an advantage in renting land and will expand.
- There is a significant gap between those farmers who are prepared to adopt this technology and those who are skeptical and/or fearful of it.

Therefore, the farmer organizations and the ag retailer organizations within Iowa AgState should assist their constituents in adopting the technology.

Four key issues surfaced repeatedly throughout the assignment as interviewees grappled with the implications of Digital Agriculture. These key issues were:

1. Will all of the components of Digital Agriculture combine to create a major “inflection point” in productivity similar to the introduction of hybrid corn many decades ago?
2. Will Digital Agriculture cause the row crop sector to become integrated, i.e., coordinated through contracts with farm operators by a few large ATPs or a handful of large corn and soybean customers?
3. How rapidly will consolidation occur within the row crop sector and among ag retailers?
4. Will the sophisticated agronomy models allow computers to provide agronomic advice with little local agronomic input?

While it is impossible to predict with precise accuracy how the technology will develop and how the industry will shift, the statements below represent credible scenarios for each of these questions.

1. During the next four years or so, Digital Agriculture will probably provide gradual improvements in productivity; however, beyond this time period Digital Agriculture has the potential to make significant step-function improvements in productivity and profitability.
2. It is unlikely that the major ATPs will attempt to integrate row crop production; however, it is conceivable that major corn and soybean customers might attempt to do so to manage their business more efficiently and control product quality more effectively.
3. Digital Agriculture is likely to accelerate consolidation of farm operators and ag retailers. In this respect it is no different than other new technologies introduced to agriculture.
4. Computers will assume a much greater role in the processing and interpretation of agronomic data in the future. Given the complexity of weather, crop diseases, and

agronomic variation, human judgment will always be required to some extent – but not in the same way as is presently the case.

6. A Farmer-Centric Strategy

The five major initiatives of the farmer-centric strategy adopted by Iowa AgState are:

- **Education:** Provide continuous, on-going education for farmers, ag retailers, other local businesses, and policy makers that will enable them to make informed decisions.
- **Data Warehouse:** Create an independent, farmer-controlled data warehouse for farm level data and aggregated agronomic data which can be used to better serve farmer participants.
- **Assessment:** Create mechanisms to provide an assessment of the many products, services, and business models in the market while promoting uniform, agreed-upon industry standards and guidelines.
- **Technology Pull:** Drive a “technology pull” strategy focused on products and services that provide solutions to farmer problems rather than just complicated tools.
- **Research:** Create a center for inter-disciplinary research that will position Iowa farmers to be at the cutting edge of digital technology for generations to come.

7. Next Steps

The strategy described above requires the collaboration and financial resources of many organizations beyond Iowa AgState and beyond the State of Iowa. This effort must now “pivot quickly” to engage the support and engagement of national agricultural organizations and state organizations in other states. The Iowa AgState project should be combined with other efforts that are seeking to shape the emergence of Digital Agriculture from a farmer-centric perspective.

The Board of Directors for Iowa AgState has approved the above strategy and is now pursuing efforts to expand the base of support for the strategy described in this report.

B. THE NEW DIGITAL TECHNOLOGY

During the course of the project the consulting team realized that a choice was required between a project with a tight focus on Big Data and a project with a broader focus on the Digital Transformation of row crop farming. The latter option was adopted since it would enable the development of a broader understanding of the key trends driving change and place the development of Big Data in the correct context.

1. Introduction to the Technology

The Digital Transformation of row crop agriculture is being driven by the rapid development of computer and communications technology in the U.S. economy, and the successful development of Precision Agriculture over the last 20 years. The wide adoption of yield monitors, GPS technologies and variable application equipment for seeds, fertilizer and chemicals has enabled the development of computer generated prescriptions which have been introduced during the last few years.

Currently, U.S. agriculture is at the leading edge of these broad trends, and a recent article by Professor Michael Porter of the Harvard Business School and James E. Heppelman used row crop farming as a case study to identify the major phases of digital transformation.

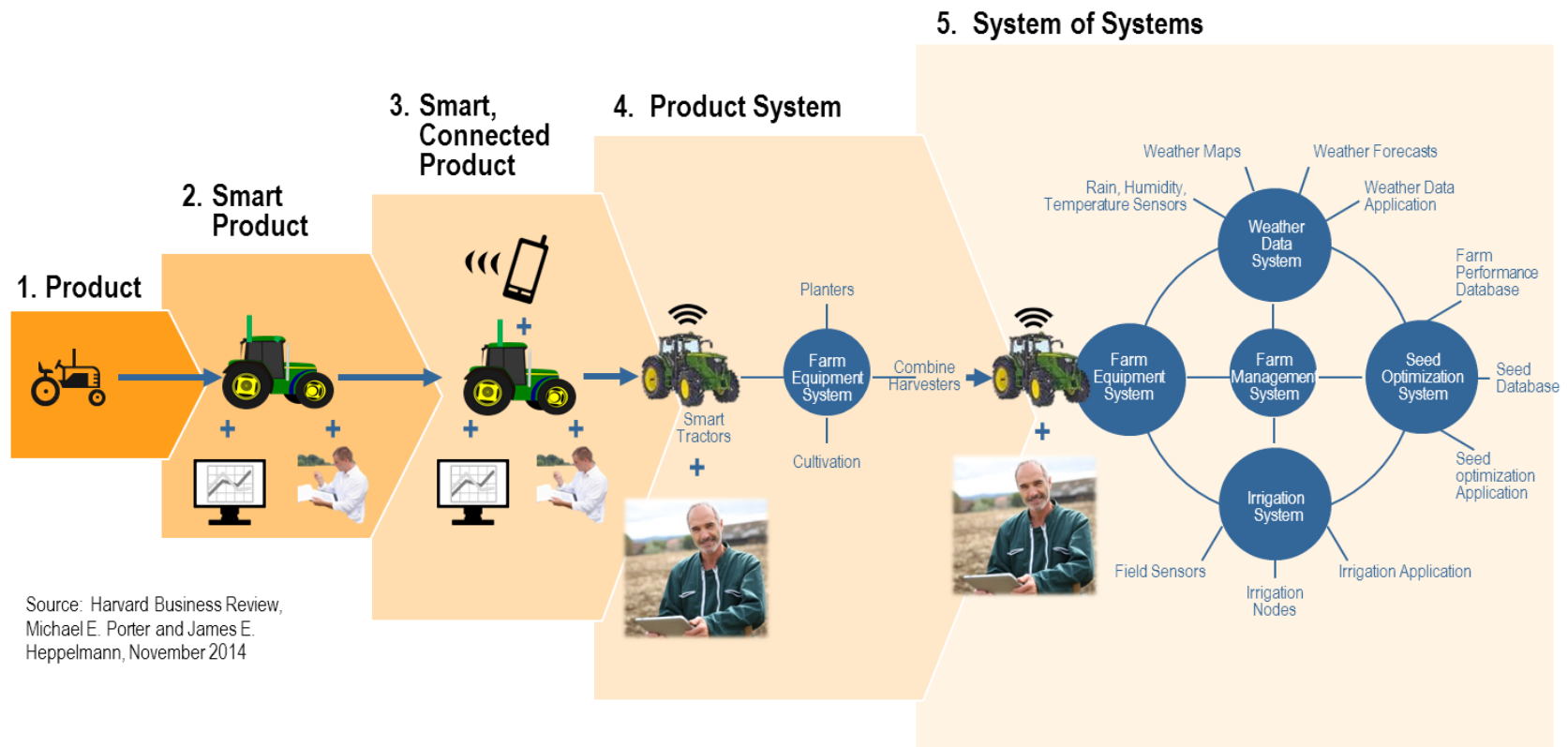
Figure 1. The Major Phases in the Digital Transformation of Row Crop Agriculture

Major Phase	Examples	Development Status
Product	<ul style="list-style-type: none"> The traditional tractor which provided mechanized power on the farm 	<ul style="list-style-type: none"> Farm mechanization in the past. This is a mechanical-human system.
Smart Product	<ul style="list-style-type: none"> A tractor or other equipment with the ability to capture performance and other data. Data transfer is via a card or stick. 	<ul style="list-style-type: none"> This development commenced in the early 1990s with the introduction of yield monitors, etc. It is still mainly a mechanical-human system.
Smart Connected Product	<ul style="list-style-type: none"> A tractor or other equipment that can collect data and is connected via wireless to the cloud. 	<ul style="list-style-type: none"> This has become viable during the last 5 years and is now the state of the art. It has a computer-human-mechanical balance.
Product System	<ul style="list-style-type: none"> A group of fully connected farm machines that perform functions such as planting, cultivation, fertilizer and chemical application, harvesting, and function as an integrated system. 	<ul style="list-style-type: none"> The most advanced farm operators can achieve this level today but there are major issues of incompatibility. It is more computer driven than mechanical-human driven.
System of Systems	<ul style="list-style-type: none"> This is Enterprise Agriculture as, defined above, with all of the operational systems on the farm connected in an optimized manner. 	<ul style="list-style-type: none"> This is still in development but represents the future. While largely computer driven, the human element is still important due to the biological nature of agriculture.

Source: Harvard Business Review, November 2014

A visual representation follows.

Figure 2. The Digital Transformation of Row Crop Agriculture



Source: Harvard Business Review, Michael E. Porter and James E. Heppelmann, November 2014

At the level of implementation on the farm, Digital Agriculture can be understood as a cloud based “system of systems” that includes the following:

- Remote sensors and smart farm machines that extract and store public and private agronomic data, machine data, and weather data in the cloud.
- Machine and human networks that collaborate in the generation and use of data.
- Farm-specific financial and accounting data systems.
- Big Data and Big Analytics that use computer-based algorithms and data analysis.
- Data visualization for human interpretation of insight and information.
- A communication system for the sharing of data, decisions and implementation plans with the right people, machines and vendors at the right time.

While the technology is available to generate and use a vast amount of data, several data collection and use challenges have been identified:

- Human Capital: Farmers need to be Tech-Savvy and to have access to IT skills for use of data in decision making.
- Quality Data: The majority of the data generated currently is not useable due to poor quality, e.g. lack of calibration.
- Data Access: Much of the data is on cards, sticks, hard drives or in binders of printed documents making access difficult.
- Better Analytics are required to automate the analysis of imagery and maps.
- Agronomic data held by ag retailers that is not easily available for farmer use and aggregation in a broad manner.

To meet these challenges the following key enablers have been identified:

- More Embedded Knowledge in the equipment, devices or systems that are developed so that they are easy to use by farmers.
- More standardization across the wide range of products, services, and systems that are being offered.
- Validation processes for services offered and business models.
- Effective security for data held both on-farm and off-farm.
- Technology Pull processes that empower farmers to define problems and influence innovation.
- User Training that can be accessed by the broad population of farmers.
- Attracting data scientists, software engineers, and computer scientists to the sector.

2. The Technology Map

The following approach was developed to categorize the vast number of products, services, and technologies being offered in the sector. Six major types of products and services and three key technology drivers have been identified. For this report, the map will be presented in the form of two 3x3 matrices. The illustrative examples provided are considered appropriate based on the information collected and the analysis of the consulting team.

Figure 3. Technology Map-Matrix 1

	Precision Ag Equipment	Data Warehouse	Ag Retailer Software
Data Generation & Capture	<ul style="list-style-type: none"> • John Deere • Trimble/CaselH • Raven • 640 Labs • Ag Leader 	<ul style="list-style-type: none"> • Geosys-LOL • GeoVantage • SST Software 	<ul style="list-style-type: none"> • SST Software • Ag Junction • SMS • Premier Crop • Raven
Cloud & Computer Processing Capacity	<ul style="list-style-type: none"> • MyJohnDeere.com • Trimble • Ag Leader 	<ul style="list-style-type: none"> • WinField Data Silo • Mapshots • GeoVantage • Amazon Web Services • SST Software 	<ul style="list-style-type: none"> • SST Software • Ag Junction • Premier Crop • Raven
Delivery Systems	<ul style="list-style-type: none"> • Trimble • BASF 	<ul style="list-style-type: none"> • Answer Tech • Mapshots • SST Software 	<ul style="list-style-type: none"> • Agronomists -- ag retailers • Crop advisors

The definitions for each vertical column are as follows:

- Precision Ag Equipment includes precision ag tools, smart machines, yield monitors, and telematics – all of which generate on-farm data.
- Data Warehouse includes data generation and storage of farm data that is collected from many sources and used for data sharing.
- Ag Retailer Software includes the specialized software packages used by ag retailers and crop advisors to serve farmers and for internal logistics and operations by ag retailers.

Figure 4. Technology Map-Matrix 2

	Smart Data Deterministic Models	Probabilistic Models	Farm Enterprise System
Data Generation & Capture	<ul style="list-style-type: none"> • Farm Data to Vendor Cloud • Seed company data • Public data – weather & soil types • Market data 	<ul style="list-style-type: none"> • Farm Link/True Harvest. • The Climate Corp. • AGSOLVER 	<ul style="list-style-type: none"> • Current vendors and buyers: • Agronomic data • Farm Accounts • Machine data in future • Ag retailer data
Cloud & Computer Processing Capacity	<ul style="list-style-type: none"> • Encirca* • 360 Yield Center • My Farms 	<ul style="list-style-type: none"> • The Climate Corp • True Harvest • IBM • Farmer’s Business Network-FBN 	<ul style="list-style-type: none"> • Conservis • Granular • Farmlogs • MyAgCentral
Delivery Systems	<ul style="list-style-type: none"> • Encirca* • My Farms – regional seed companies • Beck’s Seed 	<ul style="list-style-type: none"> • True Harvest • Climate Basic • AGSOLVER • FBN 	<ul style="list-style-type: none"> • Advisors to farmers • Vendor IT customer support

*Elements of the Encirca model are probabilistic

The definitions used for each vertical column are as follows:

- Smart Data Deterministic Models include good quality, corrected farm data and utilize key variables with point estimates based on averages.
- Probabilistic Models provide outcomes in the form of a probability distribution rather than an average point estimate.
- Farm Enterprise Systems are integrated software applications with a common process that includes farm level planning, purchasing, field operations, inventory, marketing, accounting, and financial elements.

The Technology Map provides a mechanism to understand the vast array of products and services being offered to farmers and to categorize these offers for purposes of comparison.

We recommend the use of this structured approach for educational purposes and for the evaluation of the products and services that are offered to farmers taking into account the fact that each product/service category tends to be a silo with limited horizontal connections.

3. The Key Players

The following assessment of the key players has been developed based on a modified Gartner analysis using the “completeness of the company vision” and the “ability to execute” as the key dimensions. Gartner Inc. is a leading information technology research and advisory company. The definitions below have been modified to suit the needs of this project.

The definitions used are as follows:

- **Leaders** execute well against their current vision and are well positioned for tomorrow.
- **Visionaries** understand where the market is going or have a vision for changing market rules, but are still at an early/beta stage.
- **Niche Players** focus successfully on a defined segment.
- **Challengers** are executing on their vision but still need to establish a position in the market.

Figure 5. Assessment of Key Players

	← Completeness of Vision →	
↑ Ability to Execute ↓	Challengers	Leaders
	<ul style="list-style-type: none"> • AGCO • CaseIH • Mapshots • Raven • Trimble 	<ul style="list-style-type: none"> • John Deere & Co • Dupont Pioneer • Monsanto TCC • SST Development • WinField LOL
	Niche Players	Visionaries
	<ul style="list-style-type: none"> • Ag Junction • Ag Leader • Conservis • GeoVantage • MyFarms 	<ul style="list-style-type: none"> • AGSOLVER • Beck's Hybrids • Farm Link/True Harvest • FBN

This assessment is a snapshot at a single point in time, and given the dynamic nature of the business the assessment can be expected to change as new products and services are introduced to the market.

All of the players identified are well regarded participants in the market with competitive products and services. Some companies are more focused on a specific segment of the market at this stage – such as the Niche Players. Other companies have very interesting offers but are at an early stage of development as with the Visionaries; the Challengers are executing well on a more limited vision.

The five key players that have been identified as Leaders based on the interviews and desk analysis during the course of this project all have a well-defined vision and are demonstrating the ability to execute on that vision. The next section of this report will focus on these five players and present their platforms in more detail.

C. COMPANY POSITIONING AND BUSINESS MODELS

1. Company Platforms

The following table sets out the structure of the platforms for John Deere & Co, DuPont Pioneer, and Monsanto/The Climate Corp. The backend indicates how the services are developed, and the frontend indicates how the services are delivered. The main user targets for each company are also identified.

Figure 6. Company Positioning: Backend and Frontend

	Deere & Co.	DuPont Pioneer	Monsanto/TCC
Backend Structure and Partners	<ul style="list-style-type: none"> • Software Cos: 100+ • Ag Gateway: 85+ companies • JD Link • IT Staff: 600-800 • API Developers 	<ul style="list-style-type: none"> • John Deere & Co • DTN • USDA • Land Grant Universities • AGCO • Raven • Pioneer Agronomy • Encirca Tech Group 	<ul style="list-style-type: none"> • Climate Corp: 200-300 IT staff • Precision Planting • Monsanto Seed Group • AgGateway • OADA • CaseIH
Frontend Structure and Partners	<ul style="list-style-type: none"> • John Deere Dealers • MyJohnDeere.com • DuPont Pioneer • Growmark • Dow Agro • BASF • Bayer Crop Science • Ag retailers 	<ul style="list-style-type: none"> • Encirca sales agents • Encirca.Pioneer.com • Pioneer seed sales agents 	<ul style="list-style-type: none"> • Climate agronomy reps • Climate. Com • Crop insurance agents • Helena • Growmark • CPS • WinField / LOL • Ag retailers
Target Users	<ul style="list-style-type: none"> • Farmers 	<ul style="list-style-type: none"> • Farmers 	<ul style="list-style-type: none"> • Farmers

A summary of the current positioning for each company is as follows:

John Deere & Co

- The data based service business is a major strategic focus for the company with about \$1 Billion invested and a long term target of 20%+ of corporate revenues.
- The focus has been on data generation and capture from the JD machines using a closed proprietary software system.
- The company is open to partnering with whoever wants to partner; conditions for these agronomic partnerships are not public at this point.

DuPont Pioneer

- New data based services are a strategic priority for DuPont Pioneer with an established revenue target of \$500 million in 10 years. The brand name is Encirca Services.
- The Encirca business is separate from the U.S. seed sales system and is considered to be brand neutral regarding seed and equipment.
- Encirca services focus on the technical and economic aspects of farming that drive productivity and profitability.

Monsanto / The Climate Corp.

- This is a major strategic priority for Monsanto with about \$1.25 billion invested and having the goal of establishing a new business segment that contributes to earnings within five years.
- The services are being developed on the basis of an open source approach to software with the key elements being: (1) measurement of the farming world; (2) development of probabilistic models that are proprietary; (3) development of tools and apps that deliver insights and recommendations to farmers. The Climate Corp is willing to collaborate with a wide range of partners.
- Most of the data used, such as weather and soils information, is from the public domain but the models will perform more effectively if actual farm data is provided.

The following table sets out the structure and platforms for SST Software and WinField/Land O'Lakes. The backend indicates how services are developed and the frontend indicates how the services are delivered. The main user targets are also identified.

Figure 7. Company Positioning — Backend and Frontend

	SST Software	WinField / Land O'Lakes
Backend Structure and Partners	<ul style="list-style-type: none"> ● SST Software: 75-100 staff ● Data warehouse ● AgX platform ● Raven Slingshot ● Ag Gateway: 85 + cos 	<ul style="list-style-type: none"> ● Geosys: Answer Plot: R7 tool ● Climate Corp ● Answer Tech: Winfield Data Silo ● Ag Gateway: 85+ cos ● OADA: 9 cos
Frontend Structure and Partners	<ul style="list-style-type: none"> ● Helena ● Ag Retailer A ● Ag Retailer B ● Co-op A ● Co-op B ● Crop consultants 	<ul style="list-style-type: none"> ● WinField.com ● Co-op A ● Co-op B ● Ag retailer A ● Ag retailer B
Target Users	<ul style="list-style-type: none"> ● Retailers and crop consultants 	<ul style="list-style-type: none"> ● Retailers and large farm operators

A summary for the positioning of each company follows:



SST Software

- A technology company focused on providing IT technical infrastructure, data warehouse and data processing services to ag retailers and some farmers. Currently SST touches about 82 million acres in the U.S. and over 100 million acres globally.
- Fertility models for ag retailers and local co-ops are a key product; these models can be customized for each retailer and sold under a private label.
- AgX is a new addition to the SST platform that overcomes the current issues with the lack of standards in the industry, incompatibility, and fragmentation of the services provided to farmers.

WinField / Land O'Lakes

- WinField is the leading customer for all of the major U.S. seed companies with the exception of Pioneer. The key focus of the data services business is on supporting seed sales and proprietary product businesses.
- The main route to market is via the local cooperatives with a dedicated team using the “train the trainer approach.” WinField / LOL is also supporting the retailers in introducing the technology to the largest growers.
- Significant internal capabilities have been acquired or built, and an important partnership has been established with The Climate Corp.

2. Business Models

The major findings relating to business models are that: (1) the industry has not yet settled on well-defined models, and (2) the industry has yet to establish clear value for the new services being offered.

The following table is focused on specific tools and solutions with an evaluation of whether or not clear value has been established. There are several well accepted tools where value has been established but there is also a large gap for solutions that have clear value.

Both industry participants and farmers have expressed the need for solutions. A number of potential value creating solutions have been identified; after greater experience has been gained, it will be possible to define value for these. Several of the tools and apps are at the launch stage and thus have not yet had sufficient experience to establish value.

On the positive side, it should be noted that many beta testers believe that the potential for value creation and capture is significant, and they continue to be very interested in the new products and service being offered. The major potential sources of value are agronomic value, operational management and logistics, crop budgeting at the sub-field level, and efficient information sharing.

It will be necessary to define value clearly before sustainable business models can be defined.

Figure 8. Establishing Value is a Challenge

	Tools	Solutions
Clear Value	<ul style="list-style-type: none"> • Auto steer • Variable rate seeding/fertilizer • Aerial imagery • Telematics 	
Unclear Value	<ul style="list-style-type: none"> • Yield Maps • UAVs • Local weather • Scouting apps • Multi-hybrid planting 	<ul style="list-style-type: none"> • Current prescription models • Nitrogen management systems. • Farm Enterprise systems • Benchmarking

As business models become more defined, the following criteria are proposed to evaluate the models. This evaluation can be carried out at the level of the individual farmer or by an organization that is independent of the ATPs.

Figure 9. Criteria to Evaluate Business Models

Criterion	Evaluation Methodology
<ul style="list-style-type: none"> • Economic value generated 	<ul style="list-style-type: none"> • Yield increase • Reduction of input costs • Other cost savings
<ul style="list-style-type: none"> • Cost of the product or service 	<ul style="list-style-type: none"> • Subscription and software fees • Cost per acre with a minimum • Sharing of value generated • Share of yield per acre • Investment amount
<ul style="list-style-type: none"> • ROI for products or services 	<ul style="list-style-type: none"> • DCF or economic payback
<ul style="list-style-type: none"> • Transparency of pricing 	<ul style="list-style-type: none"> • No hidden fees or costs
<ul style="list-style-type: none"> • Standalone or tied product/service offer 	<ul style="list-style-type: none"> • Bundled/unbundled with other products or services
<ul style="list-style-type: none"> • Data ownership, use and control 	<ul style="list-style-type: none"> • Farm Data: Permission sharing system • Aggregated Data: Ownership and farmer access
<ul style="list-style-type: none"> • Vendor Independence 	<ul style="list-style-type: none"> • Product/service agnostic
<ul style="list-style-type: none"> • Software approach by ATP 	<ul style="list-style-type: none"> • Closed proprietary or open source software

Additional findings regarding the potential economic benefits for farmer:

- A survey conducted by the American Farm Bureau Federation recently reported that farmers indicated that the use of precision technologies have reduced input cost by 15% on average and increased crop yield by an average of 13%. This is consistent with the survey and focus group findings.
- Based on the input received from “Innovators” in the focus groups, it is estimated that, using the best available Digital Technology and high quality data, it would be possible to achieve an incremental economic gain of \$33-62 per acre of corn. The key assumptions are: (1) corn yield gain of 5-10 bushels/acre, (2) corn price of \$3.50 per bushel, (3) nitrogen savings of \$25-30/acre, and (4) an ATP fee of \$3-10 per acre. The benefit is clearly significant in the current economic environment and will support continued testing of the new technologies by progressive farmers.

3. Key Conclusions Regarding Technology and Business Models

- The Digital Transformation of row crop agriculture compares with past technological changes such as mechanization, hybrid seeds, and biotechnology.
- Digital Agriculture builds on Precision Agriculture tools and systems that have been developed and adopted over the last two decades.
- Data stewardship both in terms of privacy and security is a major challenge that will be prevalent for a long time.
- Digital Agriculture is still at an early stage of the adoption, and there is still time to shape both the technologies and the manner of adoption.
- Farmers are faced with a vast array of new products and services that do not have common standards so there is a major systems engineering problem to be solved.
- Decision-making in the future will be a complex mix of human and computer factors.
- It will be necessary to define value clearly before sustainable business models can be defined.

D. THE EDUCATION CHALLENGE

1. Summary of the Farmer Survey

During the course of this project, an electronic farmer survey was conducted. Iowa Farm Bureau Federation, Iowa Soybean Association, and Iowa Corn Growers Association promoted the web-based survey to their constituents. A total of 384 farmers participated in the survey.

Major findings from the multiple choice questions of the survey included:

- The primary reasons for experimenting with new tools in agriculture are:
 - Increased profitability
 - Higher yields
 - Increased overall farm productivity

- Many of the Digital Agriculture products and services currently on the market are complex and difficult for farmers to use.
- Roughly 80% of farmers taking the survey are concerned or extremely concerned about unauthorized access to their farm data.
- The most trusted sources of information about new products and services, in descending order of trustworthiness, are:
 - The farmer's ag retailer agronomist
 - The farmer's seed salesman
 - An independent crop consultant
 - The Extension Service staff person
 - Neighbors
 - The farmer's equipment dealer

After numerous multiple choice questions, the survey concluded with the open-ended question,

"What other thoughts or comments would you like to share about precision agriculture or prescription agriculture?"

The 95 responses to this final question can be grouped into three major categories:

1. Skeptical and/or Fearful of the New Technology – 65%

- The biggest concern is misuse of farm data by ATPs, activists, government, hackers, and grain traders.
- Some fear that it favors the large farmers.
- Concerns that prescriptions will recommend only some products, i.e., are biased.
- It doesn't work. Agriculture is a complex biological system.

2. Neutral or Nuanced in Attitudes – 19%

- It has potential, but must be implemented carefully.

3. Embracing the New Technology – 16%

- The technology is here to stay. Let's embrace it and make it work for us.
- No one that is highly profitable today is doing it with only their own ideas and crop data.

The major educational needs of farmers – as derived from the farmer survey, the farmer interviews, and the farmer focus groups are:

- A clear explanation of how to understand the new Digital Agriculture technology.
- An assessment of whether the new tools actually perform as indicated by the manufacturers.
- An assessment of the legal documents that farmers are required to sign when purchasing the new products and services.
- An independent evaluation of the economic benefit of the new technology.

2. Summary of the Agronomist Survey

During the course of this project, an electronic survey was conducted with agronomists across Iowa. The Agribusiness Association of Iowa and the Iowa Institute for Cooperatives promoted the web-based survey to their constituents. A total of 215 agronomists and managers of ag retailers participated in the survey.

The agronomists expressed many of the same concerns and attitudes expressed by the farmers. For example, three of the major concerns among agronomists were:

- The potential use of the massive amounts of data for government regulation.
- The unauthorized access of data through computer hackers.
- The acceleration of consolidation of farm operators and ag retailers.

However, the above concerns were somewhat less strongly expressed by the agronomists than the farmers. That is, both groups expressed these as serious concerns, but the farmers were much more adamant about these issues.

The agronomists also believed that the new technology posed business threats and opportunities for the ag retailers.

The investment required at the ag retailers to serve the new technology may intensify competition among retailers and force some to exit. In addition, the ATPs may compete with ag retailers through the new services provided by the ATPs. In both cases, competition for ag retailers will likely intensify significantly.

On the other hand the new technology may provide new business opportunities for ag retailers, e.g., data management services for farmers and the use of UAVs for farming operations.

E. POLICY ISSUES

One of the driving issues that stimulated the initiation of this project was farmer concern about the ownership and control of farm data. During the course of this assignment, these issues were raised with a very high level of frequency by farmers in the focus groups, in the electronic survey of Iowa farmers, and in the individual interviews with farmers.

The primary issues of concern are captured in concise form by the phrases displayed in the list below.

- | | |
|---------------------------------|--------------------------------|
| ■ Farmer ownership of data | ■ Compatibility of systems |
| ■ Farmer control of data | ■ Protection of GPS |
| ■ Disclosure of data usage | ■ Regulation of UAVs |
| ■ Farmer choice for use of data | ■ Use of aggregated data |
| ■ Portability of data | ■ Consistency of agreements |
| ■ Security from misuse | ■ Simple language |
| ■ Vulnerability to FOIA | ■ Transparency and consistency |

It cannot be stated too strongly, that the vast majority of farmers have serious concerns about the ownership and control of data in relation to the major ATPs.

However, this project did not devote much effort to analyzing the underlying issues or possible solutions, by directive of the Iowa AgState Board of Directors, to avoid duplication of efforts with a national effort dealing with these issues led by the American Farm Bureau Federation along with the major agricultural commodity groups. These issues have been dealt with in a productive fashion and do not require further time or effort from this project.

In addition, AgGateway is developing standards and guidelines to enhance the ease of data exchange among different service providers that serve farmers, while the Open Agricultural Data Alliance is developing APIs that will facilitate the transfer of data to and from companies under the control of farmers. All of these efforts are invaluable and should be supported.

However, similar issues need to be resolved about the ownership and control of data at the “local level.” That is, there is no widely accepted agreement about the ownership and control of farm data between:

- Land owners and renters (or farm management companies)
 - Cash rental agreements
 - Share crop agreements
- Farm operators and ag retailers
- Farm operators and other service providers
- Chemical and fertilizer applicators
- Drone services
- Current land renters *versus* potential land renters

We believe these issues must be addressed in order to avoid costly litigation in rural communities among local business entities.

In fact, implementation of one of the strategic initiatives described later depends upon resolution of these issues.

F. CONSIDERATIONS FOR STRATEGY DEVELOPMENT

1. Overall Assessment

The business environment related to Digital Agriculture can be summarized at a high level as follows:

- This technology will continue to improve rapidly.
- Tech savvy farmers are already adopting it with enthusiasm.
- There is likely to be a major turnover in farm operators due to:
 - *The current age of farmers.*
 - *The prospect of low crop prices for the next several years.*
- The farmers that adopt this technology will have an advantage in renting land and will expand.
- There is a significant gap between those farmers who are prepared to adopt this technology and those who are skeptical and/or fearful of it.

Therefore, it is incumbent upon both the farmer organizations and the ag retailer organizations within Iowa AgState to assist their constituents in adopting the technology.

2. Problems to be Addressed by the Strategy

There are four major problem areas that the Iowa AgState strategy for Digital Agriculture should address. Each of these is described briefly in the chart below.

Figure 10. Problems to be Addressed by the Strategy

Unequal Market Power <ul style="list-style-type: none">■ Farmers do not have equal negotiating power with major ATPs■ Information asymmetry puts farmers at a major disadvantage■ There are few places a farmer can turn for detailed information	Complexity <ul style="list-style-type: none">■ Farmers find the hardware, software, and business models hard to understand■ Hardware and software is not fully compatible across ATPs■ Many companies are marketing “tools” rather than “solutions”
Legal Obstacles <ul style="list-style-type: none">■ Some user agreements limit farmers’ choices■ Some legal documents are hard to understand	Unclear Benefits <ul style="list-style-type: none">■ There is a mixture of fact and hype in the marketplace■ The economic benefit of some products is not quantified

3. Four Strategic Issues

Four key issues surfaced repeatedly throughout the assignment as interviewees grappled with the implications of Digital Agriculture. These key issues are:

1. Will all of the components of Digital Agriculture combine to create a major “inflection point” in productivity similar to the introduction of hybrid corn many decades ago?
2. Will Digital Agriculture cause the row crop sector to become integrated, i.e., coordinated through contracts with farm operators by:
 - a few large ATPs, or
 - a handful of large corn and soybean customers?
3. How rapidly will consolidation occur within the row crop sector?
4. Will the sophisticated agronomy models allow computers to provide agronomic advice with little local agronomic input?

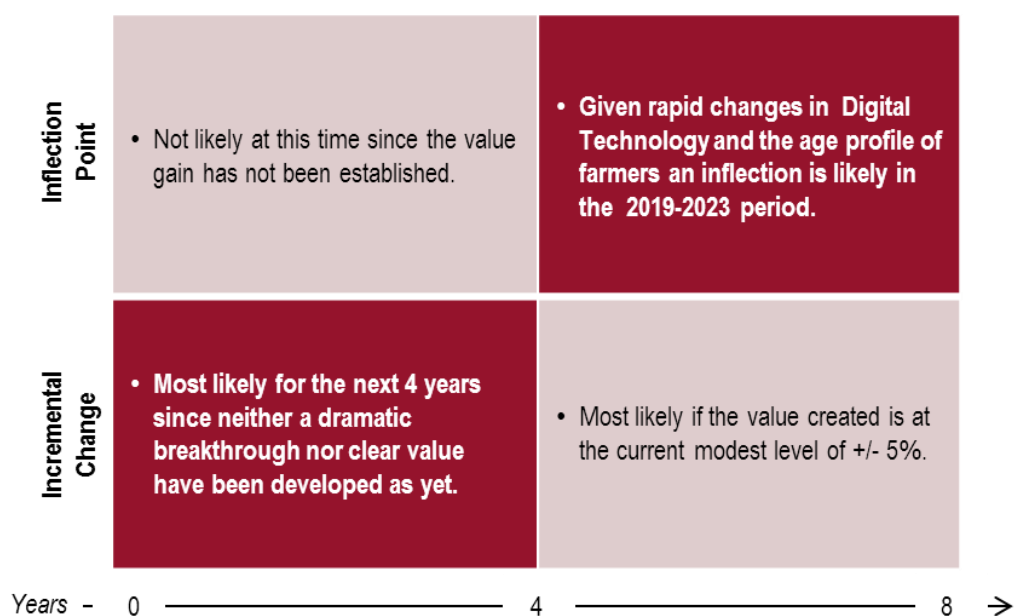
These are difficult questions, but the following presents a credible outlook regarding these complex issues.

i. Technology Inflection Point

Part of the hype surrounding Digital Agriculture is that it will cause the next great technological shift in agriculture that will cause productivity to improve in a dramatic way – similar to the introduction of hybrid corn.

Digital Agriculture is at an early stage in its development and has not yet reached its potential. The potential impact of this technology is captured in the graphic below.

Figure 11. Incremental Change or Inflection Point



It does not appear that Digital Agriculture is currently experiencing a major “step-function” upward in productivity, but the potential is there for the longer term horizon of roughly 5 to 8 years from now.

ii. Integration of Row Crop Sector

The situation is very different for ATPs and the major corn and soybean customers.

For the major ATPs, it is not likely that they will utilize the new technology to control row crop agriculture through astute use of the technology and contracts with farm operations. The major reasons for this conclusion are:

- The integrators of both the broiler and swine industry were marketing products to consumers and were trying to improve product quality to increase sales.
- The ATPs are not selling corn or soybeans to consumers.
- The asset base for row crop production is much greater than for broiler or hog production.

The major customers of corn and soybeans are not in exactly the same situation as the meat companies, but they are in a more similar situation than the ATPs. The possibility of backward

integration by the major processors through contracts with farm operators cannot be ruled out because:

- Some farmers need help using the new technology.
- Large corn and soybean users might fill the gap.
- The exit of older farmers will create an opportunity for integration.
- Large feed, ethanol, soy processors, and other industrial users could use integration to control genetics and production conditions for greater product consistency and quality.

iii. Farm Consolidation

Virtually all new technology provides greater incentive for farm consolidation; this technology is no different. Accelerated consolidation of farming operations should be expected, primarily because:

- The prospect of low crop prices provides incentives to leave farming.
- Aging farmers will likely retire while high tech, low cost producers capture more land rentals.
- This technology is simplifying operations for large-scale farmers.
- Large farmers can hire people with specialty skills, e.g., IT and agronomy.

On the other hand, one can argue that the consolidation process may be somewhat slowed because:

- Caps on total farm payments under the Farm Bill may limit consolidation in a low price environment.

iv. Computerization of Agronomic Advice

With the major advance in computer capacity and the marketing of Digital Agriculture by various ATPs, considerable discussion has centered on the way in which agronomic advice will be provided to farmers in the future. The question in its starkest form is:

Will computers replace humans in providing agronomic advice?

While it is extremely difficult to predict precisely where the new computer technology will lead, it is most likely that that human judgment will always be required in making good decisions about a complex biological operation like farming.

However, the computer power now available at reasonable cost will provide farmers with a tool of vast power that they have never had available before. Farmers will be able to control some aspects of the farming process to a degree never dreamed imaginable previously – farming small plots within a field differently and then calculating the profit per acre or per plot individually.

The importance of computerization will certainly increase, and the role of human judgment in agronomic decisions may decline, but row crop production will always require human judgment to some extent from the farmer or his trusted agronomic advisor.

G. A FARMER-CENTRIC STRATEGY

1. Vision

The vision that drives the Digital Agriculture strategy is:

American row crop producers that are globally competitive, through continuously increasing yields, reducing costs, and protecting the earth, while maintaining their business independence, choosing among many input products and services, and controlling the use of their farm-specific data

2. Mission

The mission that farmer organizations in Iowa AgState should adopt in relation to Digital Agriculture is:

To assist Iowa farmers during the Digital Transformation of Agriculture while fostering a business environment that is highly competitive and provides farmers with many business options.

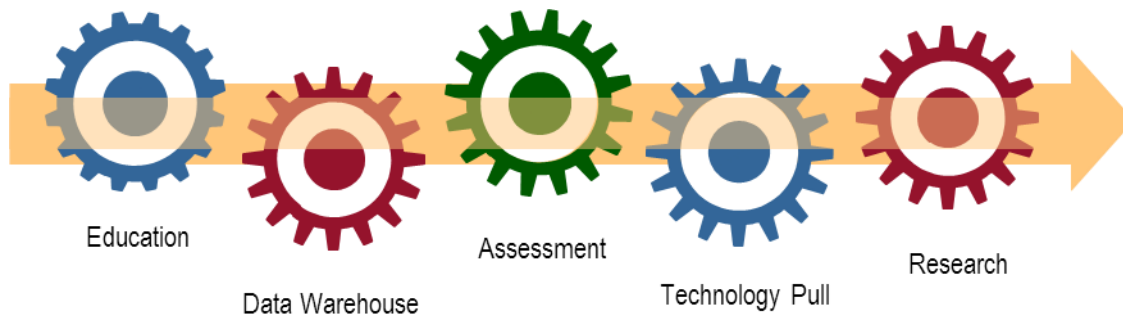
The mission that ag retailer organizations in Iowa AgState should adopt in relation to Digital Agriculture is:

To assist Iowa ag retailers to: (1) capitalize on the new business opportunities; and (2) mitigate the threats to a strong rural business environment posed by Digital Transformation.

3. Components of a Farmer-Centric Strategy

There are five components of the Digital Agriculture Strategy for Iowa AgState members as depicted in the graphic below.

Figure 12. Farmer-Centric Strategy



4. The Five Strategic Initiatives

The goals for the five major initiatives are listed below:

- **Education:** Provide continuous, on-going education for farmers, ag retailers, other local businesses, and policy makers that will enable them to make informed decisions.
- **Data Warehouse:** Create an independent, farmer-controlled data warehouse for farm level data and aggregated agronomic data which can be used to better serve farmer participants.
- **Assessment:** Create mechanisms to provide an assessment of the many products, services, and business models in the market while promoting uniform, agreed-upon industry standards and guidelines.
- **Technology Pull:** Drive a “technology pull” strategy focused on products and services that provide solutions to farmer problems rather than just complicated tools.
- **Research:** Create a center for inter-disciplinary research that will position Iowa farmers to be at the cutting edge of digital technology for generations to come.

Each of these five goals has several objectives.

1. **Provide continuous, on-going education for farmers, ag retailers, other local businesses, and policy makers that will enable them to make informed decisions.**
 - a. Distribute The Hale Group report:
 - Short and long PowerPoint presentations
 - Executive Summary Report
 - Short articles based on The Hale Group report
 - b. Conduct state-wide and regional workshops and webinars for farmers, ag retailers, and other businesses on Digital Agriculture:
 - Intensively in 2015
 - Addressing new topics thereafter
 - c. Provide the Iowa AgState Board with regular updates on the Digital Transformation of Agriculture developed for this project.
 - d. Create short videos on specific topics:
 - Provide short videos on a specific topic so farmers and retailers can learn and apply the knowledge immediately.
 - e. Educate State and Federal policy makers
 - Provide timely information about Digital Agriculture to policy makers on any issues which affect farmers and the rural economy

- 2. Create an independent, farmer-controlled data warehouse for farm level data and aggregated agronomic data which can be used to better serve farmer participants.**
 - a. Develop guidelines for the ownership and use of data among land owners, farm operators, ag retailers, and local businesses.
 - b. Define the scope and scale of the agronomic data sets currently held by farmers, ag retailers, and their software providers.
 - c. Define the costs and capital requirements for the establishment of a cloud based data warehouse for farmers that is coordinated with ag retailers. Potential options include SST and Amazon Web Services.
 - d. Evaluate business structures that would enable both farmers and ag retailers to collaborate in an independent data warehouse entity.
 - e. Develop a set of Privacy, Use and Control policies that fully protect the interests of the farmer while providing a high level of security.
 - f. Establish the required API's to facilitate access on a permission basis for trusted advisors and ATPs.
 - g. Prepare a pilot program that could be tested in 2016 with at least several hundred farmers.
 - h. Develop a strategy to optimize the value of local data if the results of the pilot project are positive and establish feasibility.

- 3. Create mechanisms to provide an assessment of the many products, services, and business models in the market while promoting uniform, agreed-upon industry standards and guidelines.**
 - a. Create a website where farmers share their assessment of specific Digital Agriculture tools similar to Amazon's book evaluation.
 - b. Create a mechanism for timely technical assessment for complex products and services similar to the Nebraska Tractor Test, Profi in Germany, or Underwriters Laboratory.
 - c. Engage with companies at early development stages so that the products launched receive early, practical feedback and reflect farmer priorities.
 - d. Create a mechanism for estimating the economic value of products and services to farmers.
 - e. Evaluate alternative business models used by industry participants in terms of clarity, benefits provided, and fee structure.
 - f. Simplify the technology through collaboration with standards organizations such as AgGateway and OADA.
 - g. Provide an assessment of the farmer-friendliness of legal documents used by manufacturers and service providers, by collecting, analyzing, and scoring the documents.

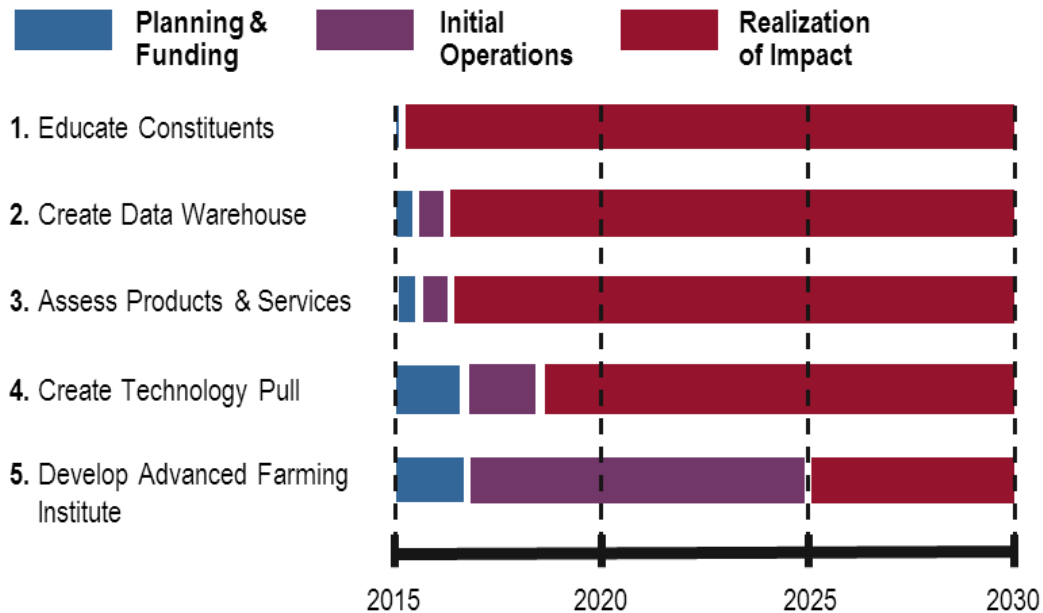
- 4. Drive a “technology pull” strategy focused on products and services that provide solutions to farmer problems rather than just complicated tools.**
 - a. Conduct focus groups and surveys to identify the key “pain points” for farmers which are not being addressed by the ATPs.
 - Farmers decide by electronic ballot what is most needed.
 - Define categories of products and services of most interest for farmers.
 - b. Conduct outreach to the tech community and ATPs so that the needs of farmers are understood and can be taken into account during the design and development phase for new products and services.
 - c. Evaluate the potential for a “Challenge Award” process as a way to influence the direction of new technology development.

- 5. Create a center for inter-disciplinary research that will position Iowa farmers to be at the cutting edge of digital technology for generations to come.**
 - a. Commence the development of an Institute for Advanced Farming that would be based on the White House Policy to create six large Innovation Institutes in the Agriculture Sector using the public-private partnership model. Leadership by ISU.
 - b. Define an inter-disciplinary research platform that includes Digital Agriculture, computer engineering, sensors, robotics, chemistry, genetics, genetic engineering, genomics, phenomics, and other non-traditional disciplines, supported by advanced simulation and predictive computer models.
 - c. Conduct an Advanced Farming Workshop at ISU that would bring together all of the interested stakeholders from within the University and across the State of Iowa under the sponsorship of Dr. Steven Leath, President of ISU, Dean Wendy Wintersteen, and Secretary Bill Northey.
 - d. Position the Advanced Farming Institute as the equivalent of the U.S. Advanced Manufacturing Institutes which focus on the development of new opportunities in that sector.
 - e. Obtain the support of the USDA and the active support of Secretary Vilsack for this initiative. This will require an updating of the PCAST study which was completed in 2012 before the importance of the Digital Transformation of Agriculture became apparent.
 - f. Adopt a coordinated approach for this initiative among Iowa AgState members and raise specific funding to support the development of an Institute at ISU.
 - g. Obtain the support of the national farm organizations since the research conducted at the Institute will be applicable across the Midwest Region.

6. High-Level Implementation Issues

The five initiatives will realize very short- to very long-term impacts. A best estimate for the timeframe for their impacts is shown below.

Figure 13. Expected Timeframe to Realize Impact of Initiatives



The five initiatives vary dramatically in investment requirements as shown below.

Figure 14. Annual Conceptual Budget Estimated Costs

Initiative	Launch Period	Establishment	Critical Mass Long-Term
#1: Education	<ul style="list-style-type: none"> • 2 FTE • \$400K 	<ul style="list-style-type: none"> • 2 FTE • \$500K 	<ul style="list-style-type: none"> • 2 FTE • \$750K
#2: Data Warehouse	<ul style="list-style-type: none"> • 5 FTE • \$1.25 MM 	<ul style="list-style-type: none"> • 10 FTE • \$2.5 MM 	<ul style="list-style-type: none"> • 20 FTE • \$5.0 MM
#3: Technical Evaluation	<ul style="list-style-type: none"> • 3 FTE • \$750 K 	<ul style="list-style-type: none"> • 5 FTE • \$1.25 MM 	<ul style="list-style-type: none"> • 5 FTE • \$1.5 MM
#4: Technology Pull Program	<ul style="list-style-type: none"> • 1 FTE • \$250 K 	<ul style="list-style-type: none"> • 2 FTE • \$500 K 	<ul style="list-style-type: none"> • 2 FTE • \$750 K
#5: Advanced Farming Institute	<ul style="list-style-type: none"> • 2 FTE-Core • \$500K 	<ul style="list-style-type: none"> • 10 FTE-Core • \$2.5 MM • \$7.5 MM-R&D-Contract 	<ul style="list-style-type: none"> • 10 FTE-Core • \$2.5 MM • \$22.5 MM-R&D-Contract
TOTAL: \$/year	\$3.15 MM	\$14.75 MM	\$33 MM
TOTAL: FTE	13 FTE	29 FTE	41 FTE

Different organizations will be the initiative leaders for different initiatives. As the project attracts more supporters, the table below will be modified.

Figure 15. Responsibility for Implementation

No.	Initiative	Initiative Leader	Strong Support Role
1	Education	Farmer Organizations Ag Retailer Orgs	
2	Data Warehouse	Farmer Organizations	Ag Retailers
3	Evaluation of Products, Services, and Models	Farmer Organizations	
4	Technology Pull Incentives	Farmer Organizations	
5	Advanced Farming Institute	Iowa State University Iowa Dept. of Ag	Farmer Organizations Ag Retailer Orgs

H. NEXT STEPS

Iowa AgState had the foresight to realize that Big Data in agriculture is becoming a force that will have major implications for the future of row crop production. It decided to provide “seed money” to assess this new technology from the perspective of row crop farmers. However, it is very apparent at the conclusion of this effort that the strategy described above requires the cooperation and financial resources of many more organizations.

This effort now needs to “pivot quickly” to engage the support and collaboration of national agricultural organizations and state organizations in other states. The Iowa AgState project should collaborate with other efforts that are seeking to shape the emergence of Digital Agriculture from a farmer-centric perspective.

The Board of Iowa AgState has approved the above strategy and is now pursuing efforts to expand the base of support for the five initiatives described above.