

To:

Rick Crawford - Chairman

US House of Representatives
Committee on Agriculture
Subcommittee on General Farm Commodities and Risk Management
Room 1301, Longworth House Office Building
Washington, DC 20515-6001

Subject: Big Data in Agriculture - Innovations in the Air

I am the founder and President of Satshot. I have been deeply engaged in developing remote sensing technologies for agriculture since the early 1990's. My accomplishments include creating the first variable rate applications map back in 1996, based on imagery and assisting in the development of agronomic remote sensing methods. My current responsibilities at Satshot include driving strategic vision, overseeing operations, and marketing the Company's products to high-value strategic accounts.

Satshot began analyzing satellite imagery for agriculture in 1994. In 1998, the Company released their first web-based GIS mapping software, becoming the first commercial user of MapServer, a NASA funded open-source software that serves as a geographic data rendering engine. In 2003, Satshot migrated its mapping database to open cloud based technology, allowing more user customization and seamless integration with more data sources.

Satshot is focused on producing and marketing satellite data products for sale to agri-business, such as production cooperatives, ag suppliers, crop consultants and also crop Insurance companies as well as to individual producers. Satshot is currently marketing the Satshot system across 400 million acres across North America and expanding around the world in countries like Brazil, Argentina, Russia, Ukraine and Australia.

Our Satshot system is also being integrated into Precision Ag systems softwares to access satellite imagery directly through their processes. Our history, current business and leading capabilities position us for exponential growth in Agriculture Sales & Marketing, Precision Agriculture, Ag Intelligence, Crop Identification, Crop Acreage Estimation, Yield Evaluation and Environmental Monitoring.

Satshot is one of precision agriculture's longest operating and most interconnected data providers, uniquely offering advanced analytics through automated processing and distribution of imagery. Satshot's cutting edge push notification system enables global delivery of updated field-specific imagery the moment it becomes available. Satshot is sensor agnostic and has the ability to bundle the entire imagery distribution chain, delivering from all sources. Image sensors have the same specifications and conform to NASA standards, thus the supply of imagery data sold by Satshot is based on the same structures of multispectral bands. As a result, Satshot's core code can enter any imagery server, including drones, and distinctively pull out imagery field by field.

The remote sensing imagery for agriculture has its official beginning back in the early 1970's when the first satellite Landsat was launched for largely to monitor agriculture. Since then technology has rapidly increased with resolution coverage and technical enhancements. The concept of using imagery to define field crop conditions is nothing new. Even in the previous decade, near infrared photography was used to define vegetation bias with photographic film. For example, all SSurgo soils maps created were based off of high resolution greyscale images taken in the 50's, 60's and 1970's

I got my start taking taking aerial NIR images of my fields in 1977 of my farm in central North Dakota. The advancements in technology has now allowed me to look at any field anywhere on the earth right from my desk or through a mobile devices in the tractor and use that image to define crop production patterns while adjusting them on the fly to manage crop inputs more efficiently for more profit gain. You can also look at crop damage to assess crop insurance loss across a field and define more accurately production and quality of the growing crop.

These real time observations and advancements are the core future of how agriculture will be managed to gain the best profitability to manage our food production system for our food security needs.

There are many way to provide image crop production data to the user. My company Satshot, specializes in satellites because of their ability to cover large area of the earth. We also use aerial and UAV imagery if desired by the customer. There are many consideration of logistics to get the proper data to the farmer cost effectively and timely. Each of these platforms whether Satellite, Aerial and UAV have their advantages and disadvantages.

Satellite imagery has a relative advantage over other types of other agronomic data layers given its comprehensive geographical coverage, lack of privacy issues, and rapidly increasing analytical capabilities. The scalability of satellite imaging also makes it the most cost effective form of coverage. Ongoing development in the private commercial satellite industry provides detailed spatial and spectral resolution imagery that allows for increasingly accurate in-season yield variability measurements, soil and water content monitoring, and harvest yield estimates. I believe that at this time that accessing any field on the earth anytime is an extremely valuable tool, that is why we focus on the satellite source as first option.

Satellite Imagery Market

New satellite launches will make consistent weekly access to in-season imagery possible, providing growers real- time crop conditions. Scheduled satellite launches will provide daily curated imagery for future growing seasons. Advancements in on board remote sensing analytic

capabilities from satellites coupled with increasing adoption rates for precision ag services in general are projected to drive considerable demand for imagery based crop health analytical products.

Recent estimates show the size of the precision agriculture market in the U.S. is between \$1.5 and \$2.0 billion. It is estimated over the next 5 years to grow at greater than 13% per annum to reach \$3.0 to \$3.5 billion. Outside the U.S., including developing countries where the need to improve productivity is even greater, the growth rate is expected to be over 25% per year. Satellite imagery offers the compelling benefit of being the fastest growing area of the precision agriculture market, while also having the highest ceiling.

The recent CropLife/Purdue Precision Agriculture Survey project that this year that over 46% of the growers are using satellite imagery, up from 33.3% in 2013. Next generation imaging promises further intensification of demand with improved remote sensing technology and increasing downstream market potential.

Satellite Imagery Data Agriculture Uses

Satellite imagery has important applications to other aspects of farm management which also include: year-to-year comparisons on a micro-area or macro basis; early detection of crop stress (weeds, disease); accurate mapping of damage (hail, floods, etc.) for insurance purposes; yield estimation of crop and acreage and others.

Satellite Imagery allows Agribusiness the visibility to precisely target their products and solutions to the right prospect at the right time and with the right offer. In addition to serving the Agribusiness sector, we provide solutions for the growers. Imagery analysis involves quantitative evaluation of satellite images for crop health vegetative growth patterns across fields.

Satellites can deliver broadscale field resolution imagery, information and analysis to the farmer/grower to use in their precision farming systems. Crops and vegetation appear differently in each spectral band, and these differences can vary due to plant vigor, soil type, available moisture, and a host of other factors.

Results of this analysis are used to supply information for precision farming operations, in assisting crop production decisions, and in making yield and quality estimates on a detailed level. Growers can draw in their field and analyze each field by acres, and build maps to scout or variable rate their field. Maps can be exported directly to variable rate controllers into their tractors or application equipment.

GIS mapped farm boundaries associated with landowner contact information and related vendors for substantially all farmland in the United States can also drive field-level distribution. Back-end tracking of notification interest and imagery distribution allows the user to build multi-layer relationship trees that identify valuable interactions within the big geo spatial data systems hierarchy user ecosystem. As a companies user base grows, these relationship networks become increasingly valuable.

Imagery analytical tools allow the grower to analyze a farm field for vegetation variability, which relates to different productivity of soils within the field. Tying this information with agronomic knowledge and farming techniques, one can efficiently apply chemicals and fertilizers where needed for improved productive capabilities. Vegetation field variability is determined by analyzing near Infrared wavelengths obtained from the satellite sensors.

By providing soil type, precipitation and the history on farm field production down to 5 square meter resolutions or better, the grower can efficiently maximize farm production by applying the right quantity and type of seed variety, the optimal amount of water and fertilizer, etc. To the dealer it provides the farm field level intelligence to recommend the optimal seed variety to the farmers or appropriate type and quantity of fertilizer.

Satellite Imagery can be available within as early as 24-48 hrs from the time the satellite takes an image. Once available, web based GIS systems allow the user to quickly submit field information over a web site, which can be turned into management information for Ag companies. In return farmer/growers can have access to incentives for crop information submitted.

Although many precision ag platforms still use the free low resolution imagery from Landsat, it has significant limitations in deciphering the sub-field variance necessary to make accurate agronomic decisions. Detailed image accuracy allows for more precise field management. Different satellites provide comprehensive offerings of high quality imagery data sources with resolutions ranging from 30 meters to 25 centimeters:

Insight into crop variability using various graphical indicators, known as vegetation indices are created by the coordination of various satellite sensor readings for electromagnetic reflectance. During the photosynthetic process, the chlorophyll in plants captures electromagnetic energy, but does so at varying levels for waves of different lengths. Vegetation indices use the variation in specific wavelength channel reflections to analyze chlorophyll content and extrapolate a field's vegetation biomass.

These analytics are accomplished by sensor reflectance readings for near-infrared, red-edge, red, green, and blue electromagnetic waves. Healthy leaves with high chlorophyll levels reflect wavelengths that distinctively fall in the near-infrared band, whereas distressed leaves absorb waves. High near-infrared reflectance corresponds with crop health. Similarly, chlorophyll strongly absorbs red wavelengths and reflects green. As such, low red reflectance and high green reflectance are both indicators of healthy plants. The different vegetation indices utilize different wavelength channel reflectance to provide a variety of field information

Imagery is increasingly viable for determining real-time intra-field yield variability, an essential component to precision ag practices. Near-infrared wavelengths show the most detailed field variability analysis of a field.

Precision Agriculture Growth

Powerful technological trends are developing within precision agriculture. These trends include increasing hardware and software adoption, cloud connectivity, and growing data standards for platform integrations. Rapid growth in the agricultural data science market is fostering companies to move quickly to penetrate the market. Many companies are developing large user geospatial bases by empowering local agronomists and dealers to make informed, graphical decisions for their clients.

Rapid growth in the agricultural data science market is fostering unprecedented levels of growth opportunities to penetrate the market. Precision Ag Data companies are building large client user bases over years by empowering local agronomists and dealers to make informed, graphical decisions for their clients.

Field Management focused on fulfilling orders for curated imagery in real-time and providing clear analytics that intentionally do not provide direct recommendations, will serve as highly effective tools for informing or validating agronomic decisions. Enhanced remote sensed imagery from different multispectral channels with multi-temporal capabilities during the growing season are coveted to quantify, project and manage vegetation changes of crops throughout the year.

The driving force behind the growth of precision farming is that patterns of productivity are highly variable within a given farm field, and that farm management provided to this micro-level of variation can significantly reduce costs, while also increasing yield. However, this does require some investment in new equipment. In addition to variable rate applicators (fertilizer, chemicals, seed, and Water) and in-field navigation equipment (i.e., GPS), a digital data map is provided from a geo referenced vegetation biomass image dataset that tells the computer-controlled applicator how much to apply based on vegetation productivity. The data in this digital map can also be based on a number of sources, such as soil tests and historical yield (from harvester monitors). Patterns detected from satellite imagery can significantly enhance, and in some cases supplant, these other sources of information.

New Satellite Technology shift

Next generation satellites improve the frequency of in-season shots, allowing real-time monitoring of crop conditions. Leading partners developing high frequency satellite imaging will soon 1-3 years operate powerful micro satellites capable of shooting more reliable, inexpensive imagery on a weekly and eventually daily basis. The increasing availability of imagery allows the ag industry to fully leverage its notification capabilities by providing actionable crop condition updates.

Tremendous disruption is underway for the satellite imaging industry, and the most notable breakthrough is the ambition of several well-funded entities to supply global satellite coverage with high-resolution daily imaging through small low-cost satellites that form constellations of "birds" of Microsats or CubeSats. The CubeSat low-orbit standard format is revolutionizing how satellites are used by providing much of the performance of a conventional satellite for a fraction of the cost by using many off-the-shelf micro technologies.

The low cost of these micro satellites enable increased launches and therefore high frequency data. This creates a radical new data set, which makes clear a need for advanced processing and distribution technologies. The paradigm shift in the satellite imaging industry is that a current lack of image availability will quickly swing towards overcapacity over the next 10 years.

The first private companies to build CubeSats already have a significant amount of traction and are entering their latter financing rounds with strong proof of concept. Critical design is complete and the focus has shifted to large-scale manufacturing and deployment. Many companies are planning to launch extensive constellations, several of which will cost in excess of \$1 billion dollars.

At the same time, traditional satellite cost is also declining and many planned launches for relatively smaller and infinitely more powerful structures exist as well. Upcoming generations of satellites will also use new technologies like short-wave infrared, which is capable of seeing through smoke, clouds, fog and other particulates. The most recent or identified upcoming Satellite launches (traditional and CubeSat) will provide consistent global coverage and a nice scale to meet agricultural needs.

Satellite imagery has a relative advantage over other imaging aerial platforms given its comprehensive geographical coverage, lack of permission issues, cost effectiveness, and rapidly increasing analytical capabilities. A single satellite image can cover millions of acres, enabling cost effective coverage.

New satellite launches will make consistent weekly access to in-season imagery possible, providing growers real-time crop conditions. Scheduled satellite launches will provide daily curated imagery for users. Advancements in remote sensing analytic capabilities from satellites coupled with increasing adoption rates for Precision Ag services in general, are projected to drive considerable demand for the industry. This increased availability of imagery will allow farmers to fully leverage image notification capabilities by using actionable crop condition updates.

Most satellite imagery is used as a crop health vegetation analyses overlaid on a precisely bound, recent satellite image of a grower's field. These images and analyses provide valuable insight for pre- and in-season crop conditions. Field image analysis employs a variety of data correction techniques on orthorectified satellite imagery and then applies a set of index algorithms which interpret channel wavelength data.

Precision Ag software systems display this data as an image, enabling growers to easily view several measures of crop variability such as biomass diversity. Primary crop health indices include NIR, NIR Red Edge, NDVIR, NDVIG, and NDVI Red Edge. These graphical indicators enable users to easily build variable rate application maps or identify precise in-field zones to scout. Currently, Satellite processed spatial resolution of 5 meters provides the ideal mix of analytic capabilities, image cost, and geographical coverage.

Many precision agriculture platforms employing imagery rely on low resolution imagery for cost savings, delivery now of 5 /10 meter resolution imagery provide a drastic improvement over the industry standard Landsat images, which are often only available 2-4 times per season. While irregularities can begin to be seen with 30 meter imagery, the reduced resolution also makes these images a less effective tool for precision applications. Distinct advantages of a high resolution quality data layer is essential for the level of accuracy for performing agronomic cross-analysis activities including definition and adjustment of management zones for variable rate applications.

For super high resolution imagery from 1 MM to 6 inch resolution, The market for unmanned aerial vehicles (UAVs) commonly known as drones will be available upon approval by the FAA, which infant drone technologies seek to fill the white space left by satellites. UAV's have a place along the modern agriculture imaging chain, and the marketplace will eventually grow once standardized, processing and delivery drone imagery will be little different than that of aerial imaging or satellites.

Despite its limitations regarding logistical processing and scalability, the commercial unmanned aircraft systems market is projected to experience growth as a result of the integration of UAVs into the National Airspace System. UAV data will be more available following clarity on legal permission issues, standardization of imagery, and decreased bandwidth utilization.

UAV's do present problems associated with managing the data load because of the massive amount of pixel data, and the stumbling logistical points of platform execution. UAV's do not currently provide scale and coverage, and are akin to fine dining for imaging. Big geo spatial data systems are being developed to capitalize on this opportunity by easily incorporating UAV data into its existing data storage and analytical framework, This will require bigger servers and more bandwidth, but future core architectures will handle any data load to scale across the agriculture sector.

A strong platform for imaging will ultimately fuse the use of UAV, satellite and aerial imaging, and capture the benefits of each source. With scalable infrastructure, these big geo spatial data systems will have the ability to expand data curation, analysis, and delivery capabilities to include diverse geospatial data in raster and vector formats, from micro-weather sources, and soil sensors, among others.

Satellites, Airplanes and UAV's will solve the problem of imagery access in the near term, and successful systems will deliver these images in a useful format to the common grower. However, capabilities in a decision support system within the cab will make the biggest impact in terms of decision-making on the farm. Distribution of real-time data streams, coupled with unbiased education regarding how to leverage this information is really the Holy Grail of platform execution. Simplifying the massive data to meet the daily needs of the common grower through decision support modules will change the farming paradigm!

Big Data - Cloud Structure - Todays Big data is tomorrows small data!

Cloud systems are becoming logical steps towards building a larger platforms for data storage, analysis, and mosaic processing, enabling distribution and management of mass amounts of satellite, aerial, and UAV data.

Service providers, resellers and operators concur that the Internet is a key enabler in disseminating (EO) earth observation data and services. Web-based platforms are becoming common for storing and distributing data sets and products, and will continue to provide innovative delivery platforms from which users can obtain data and services.

A pillar of wide-ranging user ecosystems that include leading agronomic data providers, growers, cooperatives, crop consultants, crop insurance companies, dealers, crop input retailers, equipment manufacturers, and independent dashboards will become more available. Internet platforms and distribution is expected to be the important tool for attracting enterprise and private users in the effort to bring EO data to the masses.

With these systems, Big data is now transforming modern agricultural practices by ingesting realtime field information into geospatial mapping systems. These systems along with big data allow farmers to get more out of their arable land in order to meet rising commercial agriculture production needs. There are few big data platforms which have proven to be scalable globally, particularly in areas of the world where there is limited access to historical yield, weather, water, topography and soil data to develop decision algorithms and support optimization of various agronomic models.

In more advanced agricultural markets like the United States, data platforms struggle with logistical issues like quality of data acquisition and privacy. For reasons like these, the market is becoming increasingly reliant on satellite imagery technologies to collect realtime field crop data to inform GIS models for pixel-level applications.

A focus on data cloud imagery infrastructure enables image providers to develop a range of applications that previously required complicated contracts with data providers or the maintenance of a separate geospatial database. Robust open platform user ecosystems continue to grow through an increasingly diverse group of agribusiness related entities, as third party developer momentum proliferates.

Cloud infrastructures for back-end distribution for digital imagery curation and distribution capabilities are needed to highly scale to the ag sector. Once an image is delivered, users can measure, or project growth characteristics such as early season crop vigor, biomass, or yield variations through agronomic modeling. These models may determine economic return variability, define effective management zones, or inform timing of planting, treating, and harvesting the crop.

Through the culmination of years of software development, leveraging cloud-driven distribution capabilities in a manner that provides more timely and frequent field management insights, companies like us are providing synergistic benefits and allow users to also leverage the clouds data infrastructure for easy storage, management, and sharing of their agronomic data. Cloud data systems must permit users to

import other geospatial data layers such as UAV imagery, aerial imagery, and soil sensor data. For imagery, analysis tools must be broadly applied.

Cloud Data delivery and notification infrastructures are also extending into third party software through API's (Application Programming Interface).. Core API structures must be enterprise ready and provide retrieval and batch processing of multiple value-added images from a single imagery hub. Also platform partners must be able to redistribute image products to a growing number of connected applications and users.

Push to Grower Technology

Data notification platforms are massively becoming deployable through relatively frictionless distribution. To accelerate scale, companies can intentionally omit direct recommendations, in favor of offering the most impactful set of applications and data for the use of their grower/advisor clients as support for individual judgments. The ability to link geospatial data and imagery with precision to areas within the individual farm field gives a distinct grower touch and results in the ability to deliver unique and highly relevant data. Data image hubs can effectively reach the edges of a mass user base at a fraction of the overall cost.

Distributing predominantly high-resolution imagery, directly to the cab will help ease the case for precision management and machine empowerment through automation. Solutions must be scalable for rapid integrations into large agribusinesses. Enterprises must be able to quickly set up and link users to fields through extensively attributed databases and allow tools for the creation of a hierarchy of users, which enables clients to track interactions for active field management and big data analytics which will offer unique opportunities to immediately acquire a scalable, robust, and vertically focused imaging platform for agriculture.

Platforms that are successful will tactically and strategically use cloud core code to enable a broad range of solutions for tracking user activity for social or ecosystem benefits while leveraging the cloud notification systems backbone to generate real-time, relevant dialogue with the grower. This allows scalable big data analysis through a network of APIs and advanced database-level algorithms, which users can access a system that is limitless in data-depiction and manipulation.

Mobile Apps

Mobile Image analytics software apps are now mostly cloud- driven, and used for in-field decision support solutions. These mobile applications offer analytical tools specifically focused on in-field analysis which enable users to define management zones for variable rate applications as well as track in-field crop condition events.

Scouting tools within the app also provide tracking capabilities for users to record all the harvesting, soil-testing, and scouting events that take place throughout the season. Events are linked directly to field boundaries, allowing the information to be included in any related analysis. Additionally, "Photos" tabs give users the ability to shoot in-field images of problem areas from their mobile devices. These photos are precisely geo-tagged with the geographic coordinates of where they were taken.

These mobile apps not only provide satellite and aerial imagery based analytics, but also seamlessly incorporates UAV imagery into the apps platform. When users conduct in-field biomass analyses based on satellite imagery, they are directed to specific zones of concern within the field. This streamlined process allows for targeted high resolution UAV imagery to detail leaf- level crop conditions. This synergistic use of satellites and UAV's provides the optimal mix of data storage and detail for large scale management. Mobile in the field platforms show the consultant to the variations in the field. The consultant has the option to take a picture of the affected area and beam that right to the management team back at the office for immediate management techniques.

Next-Generation Notification Capability: Automatic notification of field observations is fundamental to next generation customer acquisition and user interaction. Using multiple imaging sources to increase frequency and quality, normalizing all images, and introduce change detection algorithms in the near term and will be scalable globally, likely driving adoption of the notification center and the platform in general.

Crop Insurance Claim & Compliance Analysis

Satellite imagery has also been used extensively for 10 years or more for Crop Insurance and field loss claims.

The USDA/RMA and the crop insurance industry uses satellite imagery to evaluate crop damage and assess a more accurate loss analysis of the crop loss event. Imagery is taken from satellite archives before the damage event and another image is tasked of the area after the event. An analysis of vegetation conditions are provided by acreage and percentage of vegetative change to the adjuster in the field, resulting in a more accurate loss determination. Imagery is also used in fraud claims to evaluate losses from previous year to determine accuracy of the adjustment.

For crop loss determination, users can track crop loss claims and reports while at the same time analyzing vegetation loss through satellite imagery analysis. Features include claim tracking, map creation of field location, with GPS coordinates plus acreage of analysis using a satellite image taken 10 days of the loss. Map report generation of the vegetation zone characteristics by acre and percentage. Loss maps are printed and emailed to the loss adjuster in the field.

Imagery is also used for creation of Crop Insurance map booklets tied to historical insurance yield information. For crop loss determination, imagery is used to evaluate crop damage and assess a more accurate loss analysis of the crop loss event.

AG Intelligence

Agricultural uses of satellite imagery to date, have historically focused on broad macro-based evaluations, such as regional, national, and international estimates of acreage and yield. However, agribusiness's demand for satellite data is shifting to a more micro-based (local area, individual farm, and in-field) focus. The primary driver in this shift is the increasing adoption of precision farming techniques for increased crop input and yield maximization efficiency.

Individual field vegetation analysis of satellite data provides users access to enhanced tools to process and analyze satellite imagery of comparable fields or groups of fields. Imagery analysis involves quantitative evaluation of satellite images for patterns and trends. Crops and vegetation, can be compared by farm to farm or county by county by a host of agronomic vegetative factors.

Software platforms will continue to be developed further to provide more advanced crop monitoring tools automatically for the Agribusiness community and provide detailed reports of crop acreage conditions. This allows grain buyers/traders to quantitatively assess the impact of drought conditions. Similarly, users can use tools and datasets to evaluate crop growing conditions.

The need for future food security for evaluating crop levels will allow stability of the food supply for Worlds needs. In the past few years, volatility in crop prices has been caused by a lack of real-time information on crop conditions and their levels of productivity. For example, in the 2010 season the agriculture grain trading industry was affected by the inadequate crop information sources of the Russian wheat crop, resulting in a 50% increase of prices within weeks.

Also these past years, inaccurate USDA crops report have resulted in an increase in crop prices that has affected the stability of commodity stocks , like corn and soybeans. The ability to track crop information down to the field level and its infield variability tied to grower operator information will result in new tools to allow the food security situation to be addressed.

The ability to have real-time information of crops is invaluable for the proper pricing of commodities. Satellite imagery provides real-time crop information across the country and the world throughout.

Crop Identification, Crop Acreage Estimation and Yield Evaluation

Many new satellites have just been available in the past years. These new satellites have changed the logistics in accessing real-time growing information like never seen before. New satellites system can access 10 times more information real-time than current and previous satellites. World coverage of satellite images and data linked with field boundary data allows multiple satellite sources in varying resolution and footprints to remotely:

- Identify crops, current vegetation and crop density
- Evaluate and track crop growth trends against other regions, other years
- Assist crop insurers to estimate risk based on vegetation patterns and confirm loss claims
- Assist Farm lenders to evaluate current and potential crop income
- Provide grain buyers visibility to available grain production acres
- Early detection of crop stress (weeds, disease)
- Accurate mapping of damage (hail, floods, etc.) for insurance purposes
- Estimated current vegetation using biomass information which has been calibrated with verifiable crop data
- Precipitation and weather data
- Previous crop rotation (i.e. is their current vegetative state the product of a good crop year or crop rotation)
- 3D topographic elevation of each farm field
- Biomass Index that allows to estimate current level of vegetation in regular (e.g. every 3-4 days) intervals.
- Weather reports tied to Grower degree days and crop stages relating to Vegetation Image maps.

Other developments in the market include environmental monitoring, for carbon management and food security. Technologies allow regulators or the market to accurately define the level of total biomass carbon sequestration on agricultural land and its acreage. Identifying and monitoring actual carbon sources and carbon sinks within a given region or farm, with comparisons of net carbon dioxide emission sources amongst individual crop fields, can improve annual reporting of carbon sequestration levels per agricultural grower.

Hyper spectral Imaging

Applied research for high spectral resolution imagery in agriculture is increasing due to availability of new image sensors. This technology is expected to gain high levels of adoption in the future once new spectral libraries are created, improving efficiency and market awareness of detailed crop conditions.

The benefits of hyper spectral imagery lie in its ability to attribute a complete wavelength spectrum to each individual pixel. This creates hundreds more spectral bands than multi-spectral imagery, enabling precise measurements that support a variety of agronomic activities. This includes added accuracy for yield predictions, vegetative stress detection, seed stock differentiation, and crop tillage methodology assessments. Advancements in hyper spectral remote sensing and applied research will provide users added precision for better yield projections, vegetative stress detection, and crop quality differentiation.

Future Agricultural Imaging Trends

Curated imagery provides a powerful data layer along with robust suites of analytical tools to support longterm agronomic decision making processes. High volume satellite image distribution platforms have ben available for agriculture for a number of years, and as the commercial space industry releases next generation satellites capable of more frequent in-season monitoring, scalable, high utility components for agronomic platforms must be available for the agricultural information market

Big data will be an ever increasing concern because of the massive amounts of information we gather for defining our fields needs for more efficient production. The tech industry has the infrastructure to handle this growth. The main issues are data privacy and security concerns which need to be addressed, and the proper rules applied for secure access to agricultural data. These issues can be resolved by looking at other industries data policies, and to allow open data standards to continue to develop. Transparency of data will be key to the growth of the agriculture information industry to allow new technology to proliferate and create a robust food industry for our future growth as a society.

Sincerely,

Rodney "Lanny" Faleide
President
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Fargo ND