Task Force for Reviewing the Connectivity and Technology Needs of Precision Agriculture in the United States

Photo courtesy of South Dakota State University

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APPENDIX

Executive Summary/Introduction

The Task Force for Reviewing the Connectivity and Technology Needs of Precision Agriculture in the United States (The Precision Ag Connectivity Task Force or Task Force) arose out of the Agriculture Improvement Act of 2018 (2018 Farm Bill). The Task Force's charge is to provide advice and recommendations to the Federal Communications Commission (FCC) and the United States Department of Agriculture (USDA) on how to assess and advance deployment of broadband internet access service on unserved and underserved agricultural lands and promote Precision Agriculture for both cropping and husbandry.

The FCC established four working groups focused in greater detail on specific issues related to Precision Agriculture. These working groups were:

1) Mapping and Analyzing Connectivity on Agricultural Lands.

2) Accelerating Broadband Deployment on Unserved Agricultural Lands.

3) Examining Current and Future Connectivity Demand for Precision Agriculture.

4) Encouraging Adoption of Precision Agriculture and Availability of High-Quality Jobs on Connected Farms.

Each of these working groups has conducted extensive research and developed recommendations that address current and future challenges. The Task Force was directed to address sustainability in the deliberations of the working groups. The Task Force used the definition of sustainability articulated by USDA and the working groups were directed to apply that definition to what it meant to their unique area and the charges they deliberated on.

The following provides a summary of the findings of the four working groups in reporting order.

1) **For the 2024 term, the Mapping and Analyzing Connectivity on Agricultural Lands Working Group (Mapping Working Group)** focused on mobile and in-field connectivity, analyzing the FCC's updated mapping processes in response to the Broadband DATA Act. They assessed how well these processes meet the needs of precision agriculture and have identified several areas of improvement.

   The Mapping Working Group has developed specific recommendations pertaining to presentation of the National Broadband Map, validation and verification of the map's accuracy, the public challenge process, sustainability of the map, and awareness and outreach regarding the map. The working group is confident that implementing these recommendations will result in a map that is more accurate and relevant to the precision agriculture community.

2) **The Accelerating Broadband Deployment on Unserved Agricultural Lands Working Group** has explored several areas of recommendations to promote the buildout to accelerate deployment of broadband infrastructure onto unserved and underserved agricultural lands, including for use in precision agriculture applications. These options include specific proposals related to leveraging underused infrastructure including spectrum, novel approaches to funding and incentivizing private investment, streamlining permitting and equipping local officials with information and training.

   The proposals adopt an "all-of-the-above" approach to the technology needs of precision agriculture, consistent with the prior recommendations of the Task Force that recognized: "Achieving Precision Ag's full potential necessitates the widespread deployment of wired and wireless broadband connectivity to cover the last acre." Their most recent recommendations describe a dual-track process of deploying fiber as deeply as possible into rural areas, while promoting the deployment of wireless networks for "last acre" connectivity. To facilitate prompt action, the FCC and USDA should seek public comment with respect to the Task Force's recommendations on an expedited basis.

3) **The Examining Current and Future Connectivity Demand for Precision Agriculture Working Group** strongly recommends implementation of "Last Acre" initiatives, policies, and incentives, highlighting their critical role in ensuring national security, particularly in terms of food and water. The core objective is to extend high-capacity internet service to croplands and livestock operations, enabling broadband requirements of symmetrical 100 Mbps speeds and low latency (ideally under 10 milliseconds).

   The key drivers to achieve these connectivity goals include deploying fiber to farm and ranch premises and incentivizing the targeted build-out of high-performance wireless connectivity that provides broad, umbrella-like coverage across the entire farm. Technology is already available; the opportunity lies in securing the necessary funding and prioritizing Precision Agriculture within existing and future policies and programs.

4) **The Encouraging Adoption of Precision Agriculture and Availability of High-Quality Jobs on Connected Farms Working Group** was charged with evaluating key issues related to the adoption of precision agriculture, including its potential to address labor shortages, ways for government to promote adoption, obstacles faced by farmers, and metrics to track progress. The report emphasizes the interconnected nature of these issues and the need for broad-scale principles that can be implemented locally with Federal guidance and in coordination with Federal and state agencies, universities, and private sector industry.

The five main categories that the Task Force recommends based on working group reports are the following:

1) Improve federal broadband wireless and mobile maps and consistently verify and validate accuracy as relates to connectivity on agricultural lands.

2) Increase incentives and enact innovative policies to build out a robust broadband infrastructure to help ensure last acre coverage.

3) Future proof connectivity standards to meet the technology needs in an ever-changing agriculture sector.

4) Improve collaboration between federal agencies and State sister agencies as well as Agribusinesses including removing regulatory impediments.

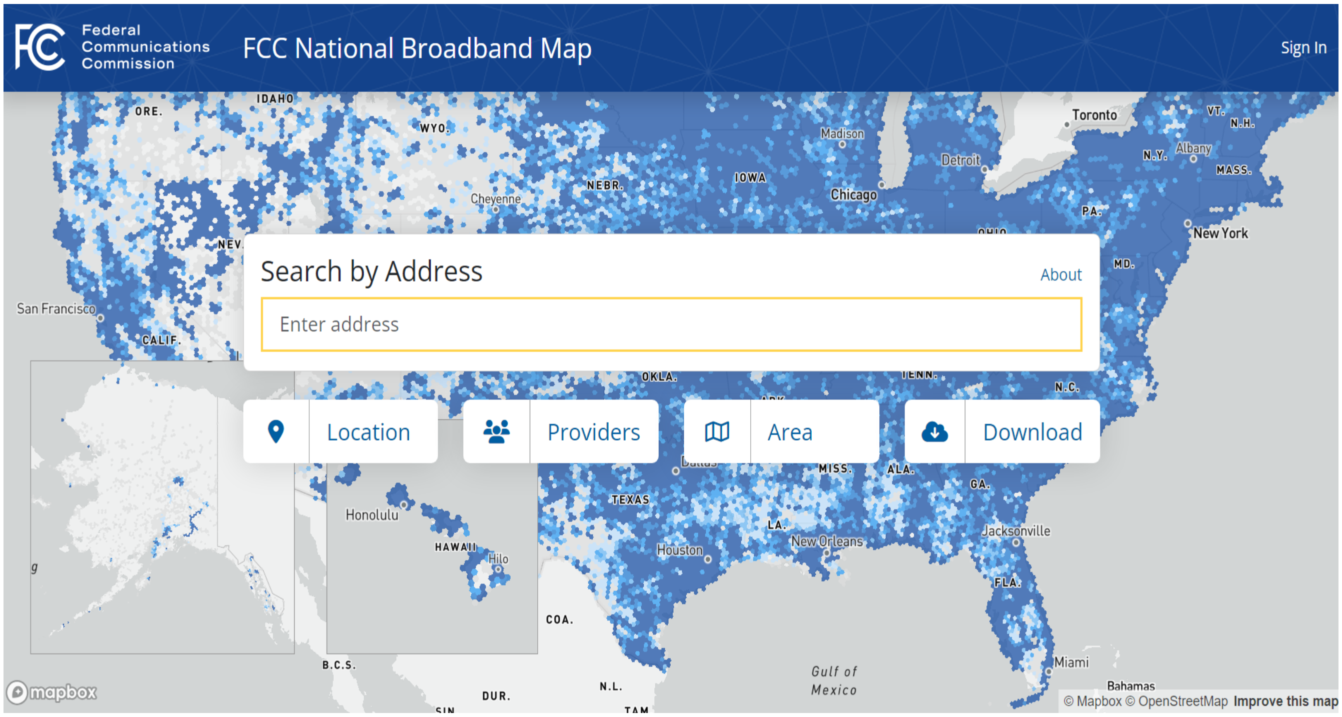
5) Increase access to broadband education and training for individuals engaged in farming through partnerships with land-grant institutions.

Conclusion:

It is evident that there are many in the agricultural community working on advocating for greater connectivity across agricultural lands to fully utilize the newest technologies to support a resilient and sustainable agriculture production system. The agriculture industry is moving to the next major evolution which is one based on connectivity and a digital data driven business.

The speed and the strength of achieving a digital data driven sustainable agriculture system through connected farms will be determined by how fast and how extensive the efforts are by both the FCC and the USDA to support the various recommendations provided by this Task Force as well as those provided by the previous two Task Forces. Finally, we would be remiss as a Task Force if we did not recommend that both FCC and USDA continue the work of the Task Force by implementing its recommendations and preserving current funding and exploring new funding opportunities.

Mapping and Analyzing Connectivity on Agricultural Lands



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Introduction

The Task Force for Reviewing the Connectivity and Technology Needs of Precision Agriculture in the United States (the “Task Force”) was created by the Farm Bill of 2018. The Mapping and Analyzing Connectivity Working Group (Mapping Working Group) was designated in the Farm Bill as part of the Task Force.

In March of 2020, after the Task Force had been Chartered, Congress passed the Broadband Deployment Accuracy and Technological Availability Act, commonly known as the Broadband DATA Act. The Broadband DATA Act requires the FCC to create a National Broadband Map. There is tremendous overlap between the Broadband DATA Act and the scope of the Mapping Working Group.

The National Broadband Map serves two main purposes: (1) informing consumers about available telecommunications services and (2) guiding federal and state government funding decisions by providing accurate data on broadband network availability. For the 2024 term, the Mapping Working Group asked, *“How well does the current National Broadband Map and its associated processes meet the needs of the Precision Agriculture Community?”*

The Broadband DATA Act expects that both local fixed Internet Service Providers (ISPs) and Mobile Network Operators (MNOs) submit coverage maps to the FCC. This act requires the FCC to verify the accuracy of the map. It further requires the FCC to develop a process by which ordinary citizens can challenge the map’s accuracy. Under the Broadband DATA Act, the National Broadband Map must include three essential layers to reflect different aspects of broadband access and coverage:

1. Serviceable Location Fabric, showing locations (Broadband Serviceable Locations or BSLs) where fixed broadband Internet access service is, or can be, installed. These are typically homes and local businesses. BSLs generally do not include community anchor institutions such as libraries, hospitals and police stations.
2. Fixed Network Availability. These are specific locations where local ISPs make mass market broadband service available. Each ISP provides information regarding where it makes such services available.
3. Mobile Network Coverage. This is a map of mobile cellular coverage. Data for the map is provided by the Mobile Network Operators (e.g. cellular carriers).

As a result of the Broadband DATA Act, the FCC created and staffed the Broadband Data Task Force. They instituted several necessary processes and created the National Broadband Map. As of August 2024, the map has gone through several revisions, and the members of the Mapping Working Group have some personal experience with the challenge process.

Early in the 2024 term, the Mapping Working Group discussed the relative importance of fixed versus mobile connectivity. The Mapping Working Group agreed that reliable high bandwidth broadband to the shop or farmhouse, which had been the focus of prior terms, is more important than mobile coverage. Mobile Service, however, is vital for in-field agricultural operations and the success of precision agriculture. Therefore, for the third term, more emphasis was placed on mobile coverage.

The Mapping Working Group also discussed both private cellular networks and mobile satellite services (as distinct from legacy fixed satellite services). Both are emerging technologies. They have great potential but have not yet reached the level where they are widely available to the mass market of precision agriculture.

The Mapping Working Group's recommendations are categorized into five areas:

1. Presentation of the Map
2. Validation and Verification of the National Broadband Map
3. The Public Challenge Process
4. Sustainability of the Map
5. Awareness of the National Broadband Map and Outreach

The remainder of this report examines specific recommendations in each category. While the Mapping Working Group acknowledges significant progress, including incorporating previous recommendations into the National Broadband Map, critical work remains to fully address the connectivity needs of the precision agriculture community.

1. Presentation of the Map

This set of recommendations pertains to the contents of the map as presented to the public. Each recommendation will be discussed and explained in turn.

Recommendation 1.1: The Mapping Working Group recommends that the mobile map reflects the performance consumers can expect, considering both RF coverage and typical network load.

The Mapping Working Group recommends that the mobile map be updated to reflect realistic performance levels that consumers can expect, considering both RF coverage and typical network load.

The Broadband DATA Act mandates that the mobile map should indicate areas where a mobile network operator's customers have a 90% probability of achieving a minimum performance threshold. For LTE, this threshold is currently defined as 5 Mbps for download and 1 Mbps for upload. However, this performance assumes specific conditions: the user must be outdoors or in a vehicle, and not inside a building. Additionally, the Broadband DATA Act requires maps to be based on a "cell loading of not less than 50%," establishing a lower limit for network traffic load. At present, the mobile map is constructed using radio signal coverage while assuming each base station operates at exactly 50% traffic load. This approach does not account for base stations that frequently experience higher loads. We recommend that the actual load data for each base station be used, rather than assuming all stations are consistently under low to moderate load.

Given the law's 90% probability requirement, we suggest that the probability-based load factor also be applied in availability calculations. For instance, if a base station operates 90% of the time at a load of 75% or less, then a cell loading of 75% should be used in performance calculations. Conversely, if a base station maintains a load of less than 50% for 90% of the time, a 50% cell loading factor should be applied, in accordance with legal requirements.

From the consumer's perspective, network performance should be represented accurately on the map, without regard to whether limitations are due to traffic load, frequency band, tower location, antenna height, terrain or other technical factors. The map should reliably reflect the typical experience that public users can expect.

In the context of precision agriculture—a primary focus of this Task Force—it might be tempting to overlook high traffic loads as a limiting factor for rural throughput. However, an industry expert indicated that rural areas often experience some of the highest network loads.

Recommendation 1.2: The Mapping Working Group recommends the addition of a 5G Performance Level on the National Broadband Map at 100 Mbps Download / 20 Mbps Upload.

The Mapping Working Group recommends that the National Broadband Map include an additional 5G performance tier, specifying a 100 Mbps download and 20 Mbps upload capability.

The Working Group "Examining the Current and Future Connectivity Demands" has analyzed the bandwidth needs for emerging agricultural equipment and concluded that 100 Mbps connectivity will be essential. This higher performance level is particularly critical for autonomous agricultural equipment, which requires substantial two-way data flow to and from data centers.

Currently, the National Broadband Map reflects only one performance level for 4G/LTE (5 Mbps download / 1 Mbps upload) and two levels for 5G (7 Mbps download / 1 Mbps upload, and 35 Mbps download / 3 Mbps upload). However, both of these 5G tiers are often achievable using legacy LTE networks, making them insufficient indicators of true 5G capabilities.

Additionally, we note that the FCC's existing broadband definition for fixed networks is 100 Mbps download and 20 Mbps upload. Although historically applied to fixed networks, this standard aligns with the requirements for advanced agricultural use cases and future mobile network demands.

Recommendation 1.3: The Mapping Working Group recommends that the FCC clarify the legend on the Mobile Layers of the National Broadband Map.

The FCC defines a “covered area” as one where there is a 90% probability that a user will meet a specified performance threshold. For example, with LTE service, the threshold is 5 Mbps download and 1 Mbps upload. This probabilistic approach is reasonable, given the many environmental factors impacting wireless performance. The Mapping Working Group acknowledges that expecting perfect reliability from wireless networks is unrealistic.

Currently, the mobile map displays “100% coverage” in many regions, which can be misleading to users who may interpret it as always guaranteeing uninterrupted service. In reality, “coverage” means there’s a 90% chance of meeting the threshold, not a guarantee of full performance everywhere. This distinction can be confusing for the general public.

To clarify, we recommend adding a well-crafted legend to the mobile map that explains the statistical nature of coverage data. This legend should ensure users understand that “100% coverage” reflects probability rather than absolute performance reliability.

Recommendation 1.4: The Mapping Working Group recommends that, by default, the satellite view be enabled on the National Broadband Map when viewing mobile coverage.

Currently, the National Broadband Map does not have satellite imagery enabled by default. It was not obvious to the Mapping Working Group that it is possible to turn on the satellite view, until we were shown by FCC Staff. We doubt the public would find it easily.

This is especially important for the Mobile layer of the map. In rural areas that do not have precise addresses, the satellite view often has visual cues that are important to precision agriculture. These might include, for example, field boundaries, irrigation ditches, tree lines, center-pivots, and so forth.

Recommendation 1.5: The Mapping Working Group recommends that mobile satellite services be added to the National Broadband Map.

Currently, broadband satellite services are categorized under fixed services, and historically satellite services that could provide broadband were fixed.
Recently, however, satellite providers have begun to make mobile connectivity available on a mass market basis. The Mapping Working Group recommends that this be reflected on the National Broadband Map.

Recommendation 1.6: The Mapping Working Group recommends that United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) produce a map that includes mobile coverage over agricultural land.
The past Mapping Working Groups have recommended that NASS create maps showing connectivity over agricultural land. Here we are specifically calling for maps that show mobile coverage, whether delivered via satellite or cellular technology. Adoption of precision agriculture techniques relies on access to connectivity. USDA NASS already produces a map of cropland.

We recommend USDA add a layer indicating where connectivity is available, so that it can be determined which areas and crops have sufficient network access to enable precision agriculture.

To enable this, FCC will need to make available the raw data from the National Broadband Map.

Recommendation 1.7: The Mapping Working Group recommends that the FCC provide a map indicating areas where TV Whitespace (TVWS) devices are permitted.

TV Whitespace (TVWS) spectrum holds great promise for precision agriculture applications due to its favorable propagation characteristics at relatively low frequencies, which enable long-range transmission. While TVWS channels are typically 6 MHz wide—narrower than the 10 MHz used in private cellular networks—they are well-suited for many Internet-of-Things (IoT) applications relevant to agriculture. Despite its potential to support connectivity for precision agriculture, TVWS has yet to achieve widespread utilization.

To support greater adoption, the Mapping Working Group recommends that the FCC publish a dedicated map indicating areas where TVWS devices can be authorized to operate. As TVWS is not yet widely available for mass-market use, this map should remain separate from the National Broadband Map.

2. Validation and Verification of the National Broadband Map

Recommendation 2.1: The Mapping Working Group recommends that the FCC establish an ongoing independent on-the-ground sampling approach to verify the accuracy of coverage maps submitted by Mobile Network Operators.

The basis for the mobile service on the National Broadband Map is data submitted to the FCC by the Mobile Network Operators (e.g. cellular carriers).
Currently, the FCC’s verification strategy is to rely primarily on collecting crowdsourced data regarding cellular network performance. That may be sufficient in urban areas. However, this strategy is inappropriate for rural, agricultural areas. By their nature, crowds simply do not gather in rural areas.

To ensure the accuracy of maps in rural areas, the FCC will need to adopt a more proactive approach.

In the Broadband DATA Act, Congress ordered the FCC to implement a proof-of-concept using United States Postal Service (USPS) vehicles to collect that data. The Mapping Working Group has reviewed the report from that trial. This seems to have confirmed the feasibility of such data collection.

The report highlighted many practical logistical challenges which need to be addressed. The report showed that this approach is not yet mature enough for widespread deployment and will require further effort and development.

The Mapping Working Group recommends that FCC establish a process for independent on-the-ground sampling of network performance data. It appears the FCC does not have processes in place to do this, and it may not be practical for the FCC to do this with its existing staff. Therefore, it may make more sense to outsource this to an independent contractor.

While utilizing USPS vehicles is one possible avenue, we also suggest that the FCC explore partnerships with other organizations that operate extensively in rural areas. Potential partners could include Google Maps, county sheriff departments, UPS, FedEx, and Amazon. These organizations have widespread presence and could facilitate comprehensive data collection efforts.

If the FCC determines that the best approach is to outsource data collection, then it becomes vital that the contractor that performs such collection is independent of the Mobile Network Operators whose networks are being measured. That is, that company should be incentivized to create as accurate, equitable, and unbiased a sample collection as possible, treating every cellular carrier equally.

We are aware that independent, on-the-ground data sampling is labor-intensive and costly. Therefore, we propose that this sampling be conducted on a statistical basis. By focusing on small, rotating sections of the country at any given time, the FCC can continuously update and evolve the sample areas, ensuring the map remains as accurate and current as possible without the need for exhaustive coverage all at once.

Recommendation 2.2: The FCC should use propagation models that are open-source and widely peer reviewed whenever reasonable.

Currently, the basis for mobile maps is that Mobile Network Operators (MNOs) compute coverage using mathematical radio propagation models and submit these to the FCC. These propagation models are statistical in nature; instead of specifying precise signal levels at exact locations, they predict a distribution of possible signal levels within an area.

Propagation models have been researched academically over many years, resulting in various models that consider factors such as antenna height, terrain, tree height, foliage density, building density, and more. Troublingly, each of these models includes several subjective factors, such as signal absorption from foliage and the human body.

At present, each MNO is permitted to submit coverage maps based on proprietary mathematical models without adhering to an agreed-upon standard. This situation is analogous to conducting accounting without Generally Accepted Accounting Principles (GAAP): while proprietary models might serve internal management purposes, they are unsuitable for verifying and comparing data across different organizations.

The Mapping Working Group reviewed provider data from the National Broadband Map and found that the three largest MNOs often use different proprietary models. Without a standardized model, it becomes virtually impossible to compare coverage between mobile network operators or detect errors or manipulations in the results.

We understand that different models may be applicable in different regions; models applied in urban areas may differ from those used in agricultural areas. However, the same fundamental propagation model should be consistently used by all Mobile Network Operators operating in the same region with similar technology (e.g., rural areas utilizing 5G mid-band frequencies).

The FCC's standardization on H3 coordinates facilitates this approach. Each H3 cell could be associated with a standard mobile propagation model.

In some situations, such as in urban areas that feature many obstructions and reflections, proprietary models may more accurately reflect true network performance than open-source models. In such cases, Mobile Network Operators should submit test data supporting their claim that proprietary models are more accurate. This will provide the government and consumers with confidence that the maps are as accurate as possible.

In rural, agricultural areas, it is unlikely that proprietary models are significantly superior to open-source models. More likely, discrepancies in measured performance result from incorrectly chosen parameters within the models.

Standardizing propagation models would ensure that parameters are consistent across all mobile network operators, facilitating accurate comparisons and validation of coverage data.

We urge the FCC to issue a Notice of Inquiry regarding how to standardize and maintain the wireless propagation models used for the National Broadband Map. These models must be open, accurate and enable comparability across systems.

Recommendation 2.3: FCC and USDA are strongly urged to advocate for further research directed towards improving accuracy of mobile mapping, especially over agricultural lands.

Deploying equipment to measure actual network performance is a necessary but costly step to ensure the accuracy of the mobile network map.

To reduce this expense, we can develop more accurate propagation models, particularly by enhancing the statistical prediction of environmental “clutter”—obstacles that affect signal propagation. Recently, new geospatial datasets have become available, providing an important foundation for these models. This data includes, for example, the size and height of buildings, characteristics of foliage, and other environmental factors. Combined with modern machine learning and artificial intelligence methods, these datasets offer the opportunity to dramatically improve clutter estimation, thereby enhancing the mathematical models upon which the National Broadband Map relies.

The Mapping Working Group does not recommend that the FCC or USDA be responsible for developing these improved propagation models. Instead, within the federal government, this research falls under the purview of the National Telecommunications and Information Administration’s (NTIA) Institute for Telecommunication Sciences (ITS), part of the U.S. Department of Commerce. Additionally, the National Science Foundation (NSF) funds several academic programs outside the federal government that could conduct this type of research, such as SpectrumX and Platforms for Advanced Wireless Research (PAWR), among others.

This recommendation is closely related to Recommendation 2.1, which suggests that the FCC establish an independent on-the-ground sampling process. Machine learning techniques rely on having a robust “training data set,” and we anticipate that the data collected through Recommendation 2.1 will be used to train these machine learning models.

3. The Public Challenge Process

As previously explained, the Broadband DATA Act requires the FCC to develop and implement a public challenge process that is specifically mandated to be “user-friendly.” Regarding the Serviceable Location Fabric and Fixed Internet Service, we believe this goal has been achieved. In most cases, ordinary citizens can readily file challenges indicating whether service is available at their address or if the correct building is shown on the map.

However, the current mobile challenge process was developed using a “big data” strategy and relies heavily on crowdsourcing. The problem with crowdsourcing is that crowds do not typically gather in rural areas. Nevertheless, everyone relies on agriculture and thus benefits from precision agriculture to some degree.

The current challenge process is far from “user-friendly,” especially in rural areas where the burden of testing cannot be spread across a large crowd. The Mapping Working Group has determined that it is unreasonably difficult for an ordinary citizen in a rural, agricultural area to file a challenge that meets the Commission’s threshold of “cognizability”—that is, to be recognized as credible and acted upon.

Recommendation 3.1: The Mapping Working Group recommends that the FCC develop a mobile challenge process that is suitable for sparsely populated agricultural and tribal lands.

The mobile challenge process is described in Section 3.1 of the FCC’s Mobile Technical Requirements document. Unlike challenges to fixed broadband service, the FCC implements “cognizability” criteria for mobile challenges. A number of challenge tests from different locations and at different times are required before the FCC will recognize a challenge as credible.

In the opinion of the Mapping Working Group, the current challenge process is unreasonable in rural and agricultural areas.

Furthermore, the FCC currently requires repeated failed tests from approximately the same location (specifically, within the same H-9 hex cell) to verify that poor performance is not the result of a temporary spike in traffic load on the base station.

On many mobile phones, the FCC speed test application can measure signal strength and other low-level parameters (e.g., tower ID, frequency) from the base station. This information is very useful and could be used to assess whether poor performance results from a poor radio link or heavy traffic load. If poor throughput is due to a weak radio link, then it is unnecessary to repeatedly test at different times.

In Section 3.1.3 of the Mobile Technical Requirements, the FCC describes the threshold for recognizing a challenge as credible. The document outlines a chi-squared test without explicitly naming it. A chi-squared test is widely used to statistically compare categorical data, such as eye color.

In this case, a speed test is performed, and the result is characterized as either “pass” or “fail.” This is an inappropriate use of the chi-squared test because the “pass” and “fail” categories are both determined based on a single numeric variable: network speed. Network speed, in turn, depends on at least two variables: signal strength and traffic load from other users. A different type of statistical test might be more suitable, particularly one designed for numeric data rather than categorical data. A T-test or Bayesian inference might be more appropriate.

The Mapping Working Group recommends that the FCC reconsider the mobile challenge process and consult professional statisticians to determine a method more suitable for rural agricultural communities where challenge data is sparse and difficult to collect. The FCC should also consider whether it is possible to compare the measured network speed with the predictions of the propagation models that form the basis of the map.

Recommendation 3.2: When a mobile challenge is submitted, the FCC should inform the person making the challenge of additional testing required for the challenge to be recognized and acted upon.

The *Mobile Technical Requirements* document explains how individual tests taken using the FCC Speed Test App are combined with other tests to determine if a challenge is cognizable. However, this step is not made clear to the typical user when they challenge network coverage using the app.

For example, when a user takes a measurement, it is assigned to a cell identified by its H3 identifier. The FCC requires measurements from at least four neighboring cells that share a common parent cell. It is unreasonably difficult for an ordinary citizen to determine the locations of these cells unless the FCC responds to the challenge and provides that information.

Currently, when a person submits a mobile challenge using the FCC Speed Test App, they need to provide their email address, phone number, and verify that they are a subscriber to the mobile network. The FCC has ample means of responding to the submission.

The Mapping Working Group recommends that the FCC send the user information regarding locations where further tests need to be performed and, if necessary, the times of day for which additional test data are required. In situations where multiple users are interested in improving a map, the test data from these users should be aggregated and anonymized.

Recommendation 3.3: The FCC must ensure that Network Operators do not inappropriately prioritize speed test traffic over ordinary network traffic.

It is theoretically possible for a network operator—either fixed or mobile—to perform deep packet inspection on traffic and determine which users are currently performing speed tests. For example, they might do this by examining the IP addresses of inbound and outbound traffic from the cellular core network.

In principle, the network operator could then prioritize traffic for those users who are running speed tests. This has two effects: it slows down traffic for all other users who are not running speed tests at that moment, and it produces artificially favorable test results.

The Mapping Working Group is aware that, currently, the FCC does not perform actual speed tests on fixed connections. That may change in the future, and this principle applies to any speed test, whether fixed or mobile.

The FCC should take all reasonably necessary steps to prevent inappropriate traffic prioritization and clarify this prohibition in its rules. One possible technical measure is to route speed test traffic through public VPN services; however, it is essential to ensure that the VPNs do not limit overall network performance.

Recommendation 3.4: The Mapping Working Group recommends that the FCC collaborate with all mobile phone manufacturers to make low level data such as RSRP, frequency, and Cell ID available on the official FCC Speed Test App.

In the United States, approximately 58% of mobile phones use Apple's iOS operating system, while 42% are based on the Android operating system. A small percentage of devices use other operating systems.

As noted in the FCC's *Mobile Technical Requirements*, Android devices currently make low-level information available to installed applications, including the FCC Speed Test app. This information includes cell tower ID, primary cell frequency, Reference Signal Receive Power (RSRP), and so forth. Notably, iOS—which has the larger market share—does not make this information available through a standard API. The Mapping Working Group understands that some individuals have found unofficial methods to access this information on iOS devices.

This information is very useful for confirming (or correcting) the propagation models that form the basis of mobile coverage maps.

The Mapping Working Group recommends that the FCC attempt to make this low-level information available in the speed test app, regardless of the operating system. The Working Group understands that the FCC has no authority to compel Apple or any other vendor to make such information available but is hopeful that manufacturers might recognize the potential usefulness and benefits.

Recommendation 3.5: The location of pending and resolved mobile challenges in the download data files should include latitude and longitude; currently these locations are identified only by H3-hex cell ID.

The FCC provides downloadable mobile challenge data, both pending and resolved, in the form of a comma-separated values (CSV) file. Currently, the location of a challenge is identified only by the H3 cell ID.

While the Mapping Working Group understands the reasons behind the FCC's adoption of H3 cell descriptors, we recognize that this system is not widely understood by the general public. Furthermore, despite extensive searching, we have been unable to find a publicly available website that can convert H3 cell IDs to latitude and longitude; the closest resources available are computer program libraries.

Therefore, to advance transparency of the process, the Mapping Working Group recommends including the center point of each H3 cell (specified by latitude and longitude) in the CSV download file.

We realized late in the term that the FCC makes mobile challenge data visible on the National Broadband Map. However, this data are only visible when users zoom in closely on the approximate area of the challenge. This further justifies having the latitude and longitude of the challenge locations readily accessible, so the public can more easily inspect challenged locations on the map.

4. Sustainability of the Map

At the beginning of the 2024 term of the Task Force, Chairwoman Rosenworcel asked the Task Force to consider the issue of sustainability.

The Mapping Working Group believes that it is evident that the practice of precision agriculture promotes sustainability. Precision agriculture enables more food to be produced using fewer inputs (e.g., fuel, fertilizer, pesticides, and herbicides) while ensuring food security.

The Mapping Working Group began its discussion of sustainability by defining the word itself. We decided that the most suitable definition came from the USDA:

Sustainable Agriculture is an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs.
- enhance environmental quality and the natural resource base upon which the agricultural economy depends.
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls.
- sustain the economic viability of farm operations.
- enhance the quality of life for farmers and society as a whole.

The Mapping Working Group feels that it is quite clear how network connectivity enables and contributes to precision agriculture and, by extension, to sustainability.

Without going into great detail, we note briefly that techniques such as low-till and no-till farming dramatically reduce CO_2 emissions into the atmosphere. Selective spraying significantly reduces the amount of pesticides, herbicides, and fungicides needed to maintain crop health, thereby improving water quality. Water management systems can make crop yields more predictable year after year. Such observations, while inspiring, do not result in specific recommendations.

We note that the NIST IoT Advisory board Final Report specifically calls out precision agriculture as one of the areas that could "...deliver significant and scalable economic and social benefits to the United States." However, the same report also observes that adoption of such technology has been slow and uneven. We believe that this is due in no small part to the lack of ubiquitous network connectivity.

We further recognize there is a great deal of truth of the old maxim "What gets measured gets managed." Network connectivity is essential to the measurement of agricultural processes. If we want to measure how often sustainable practices are being employed or the results we are achieving, network connectivity is essential to gather the necessary data.

The Mapping Working Group went on to consider how to ensure that the National Broadband Map itself is sustainable. That line of inquiry resulted in several recommendations. Fundamentally, this comes down to ensuring that staff are available to keep the map up to date with accurate information, and that requires funding.

Recommendation 4.1: Congress and FCC must ensure adequate funding to sustain the mapping process on an ongoing basis, including independent, on-the-ground testing to verify network performance.

The Mapping Working Group recognizes that there are considerable expenses associated with maintaining the National Broadband Map. FCC must maintain staff resources simply to process the data from ISPs and to administer the various challenge processes required by the Broadband DATA Act.

The Mapping Working Group believes that independent on-the-ground measurement of connectivity is required to ensure an accurate Mobile Broadband Map. We recognize that collecting such data comes at considerable cost. Nonetheless, it is reasonable to use a modest portion of whatever subsidies will be allocated to ensure those subsidies are deployed efficiently.

Recommendation 4.2: Ensure funding is available to maintain the FCC Speedtest App.

It can be tempting to plan that developing software applications like the FCC Speedtest App represent one-time expenses. Our experience has been that such applications require ongoing maintenance. Security updates and operating system changes often require modifications to Applications.

Recommendation 4.3: Congress and USDA must ensure adequate funding for finer granularity surveys and agricultural census related to technology use.

The prior Mapping Working Group recommendations encouraged FCC collaboration to enhance NASS' biennial Farm Computer Usage and Ownership Survey and quinquennial Agricultural Census to improve survey scope to include the lack of broadband coverage on agricultural lands including farmlands owned by Native nations. To improve validation of broadband coverage, broadband enabled use cases on farms, and data usage, the Farm Computer Usage and Ownership Survey should increase the granularity of survey data reporting from state to county level, via increased survey sample size. The survey results should be analyzed and incorporated into the USDA visualization platform as discussed in prior Mapping Working Group recommendations to produce a new comprehensive USDA broadband coverage map illustrating the level of connectivity over agricultural lands to examine the expansion and adoption of precision agriculture technologies.

Prior Mapping Working Groups also requested inclusion of language into the next Farm Bill to authorize sufficient funding for NASS to expand the set of broadband coverage and usage questions asked via the Agricultural Census. Such questions can be collected and analyzed as part of the existing data published from the Agricultural Census. The census results should be incorporated into the comprehensive USDA broadband coverage map to illustrate the adoption and use of broadband connectivity for precision agriculture technology.

Recommendation 4.4: The Congress and FCC should fund additional research to develop more accurate and less labor-intensive methods for maintaining the National Broadband Map, especially over agricultural and Tribal lands.

Related to Recommendation 4.1 above, the Mapping Working Group recognizes that taking in-field measurements is expensive. These measurements are necessary because:

- There is significant variance in current propagation and clutter models.
- The crowdsourcing methodology does not work effectively in agricultural areas due to insufficient population density to contribute the necessary data.

The more accurate the propagation models become; the less funding will be required for in-field verification of the map’s accuracy.

5. Awareness of the National Broadband Map and Outreach

The Mapping Working Group believes that the National Broadband Map is not well known to the general public, especially in the agricultural sector. This lack of awareness is problematic for two reasons: first, because the public cannot fully benefit from the map; and second, because the map relies on public input to verify its accuracy through the challenge process.

Recommendation 5.1: The FCC is strongly urged to promote more widely the National Broadband Map and the challenge process, especially among agricultural communities.

From the small sample of friends, family, and colleagues we have interviewed, the Working Group has found that few people are aware of the existence of the National Broadband Map. Awareness is the first step in obtaining engagement from local communities who can provide feedback regarding the map’s accuracy.
The primary responsibility for raising awareness falls with the FCC.

We also observe that the credibility and reputation of the FCC—and confidence in the government as a whole—will be affected by the accuracy of the map. Once they become aware of the National Broadband Map, many people's first reaction is to look at their own homes and nearby areas to see if the map accurately reflects what they know to be true. If the map has glaring errors, people will lose confidence not only in the map itself but also in the FCC.

Recommendation 5.2: USDA and its Land Grant partners must educate agricultural, rural and tribal communities in awareness of the National Broadband Map and its application.

The Working Group believes that one of the best ways of reaching people who work in agriculture is through the USDA and its Land Grant partners, especially the agricultural extension service.

USDA and its Land Grant partners must cooperate with the FCC in promoting awareness of the existence of the National Broadband Map, and how it benefits agricultural communities.

Recommendation 5.3: USDA and its Land Grant Partners support these same communities to actively participate in the verification and challenge process.

As described earlier, the challenge process is not as straightforward as might be hoped, especially for mobile cellular networks. USDA and Ag Extension offices provide a means to educate the agricultural community regarding ways the accuracy of the National Broadband Map can be improved.

Appendix

Chair:

Joseph Carey, Special Government Employee

Vice Chair:

W. Brad Robison, CEO, Tallahatchie Valley Electric Power Association and Tallahatchie Valley Internet Services, LLC (representing National Rural Electric Cooperative Association)

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Rick Mueller, Section Head, Spatial Analysis Research, Research & Development Division, USDA NASS

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List of Speakers and References

May 1, 2024	Scott Townley Distinguished Fellow, Spectrum and Technology Planning Verizon
May 8, 2024	Laurel Leverrier Assistant Administrator, Rural Development, Telecommunications US Dept of Agriculture
May 15, 2024	Eduard Bartholme Deputy Bureau Chief Consumer and Government Affairs Bureau Federal Communications Commission
May 29, 2024	Monisha Ghosh, Ph.D. Professor, University of Notre Dame Policy Outreach Director – NSF Spectrum X
August 28, 2024	Mike Kool Sr. Product Manager, Connectivity John Deere
August 7, 2024	Patrick Ryan, Solution Engineer Eileen Kelsey, GIS Specialist ESRI
Sept 11, 2024	Harry Crissy Economic Resource Development Agent Agricultural Extension Service Penn State University

Additionally, the Working Group Chair attended the NTIA 2024 International Symposium for Advanced Radio Technology, held June 10 to June 13 in Denver, Colorado. At this conference, representatives from Industry, Government and Academia gathered, and wireless propagation models were discussed in depth.

Documents Referenced in this Report:

The documents referenced in this report are available for download. As of October 29, 2024, these are the links:

Broadband DATA Act
https://www.congress.gov/bill/116th-congress/senate-bill/1822/text

FCC Mobile Technical Requirements Order
https://www.fcc.gov/document/fcc-releases-bdc-mobile-technical-requirements-order

Report to Congress on network testing with USPS vehicles
https://www.fcc.gov/sites/default/files/report-congress-usps-broadband-data-collection-feasibility-05242021.pdf

NIST IoT Advisory Board Final Report
https://www.nist.gov/system/files/documents/2024/10/21/The%20IoT%20of%20Things%20Oct%202024%20508%20FINAL_1.pdf

ACCELERATING BROADBAND DEPLOYMENT ON UNSERVED AGRICULTURAL LANDS

Executive Summary

Access to reliable and affordable broadband is crucial to the social and economic wellbeing of rural America. Specific to the charge of this Task Force and Working Group, broadband access is critical for the widespread deployment and adoption of precision agriculture technologies. As Chairwoman Rosenworcel explained, "Today's farmers and ranchers rely on high-speed internet to make the best use of connected tools to efficiently run their businesses and meet the demand for food to sustain our communities."[1]

But despite the general recognition of the importance of broadband availability, many parts of rural America still lack service. In its most recent report on broadband availability, the FCC found that approximately 28% of rural areas lacked access to fixed broadband at the speed benchmark of 100/20 Mbps.[2] This stands in stark contrast to the levels of broadband availability in more densely populated parts of the country, where only 2% of urban areas lack service at the same speed benchmark.[3] Similarly, approximately 36% of the population in rural areas lack 5G-NR coverage with minimum speeds of 35/3 Mbps (compared to just 2% in urban areas).[4]

The disparity of broadband deployment levels in rural versus urban areas can be attributed to many factors. The challenging economics of rural deployments is a significant reason, with higher up-front costs and lower return on investment. Poor information sharing, uncertainty around future government programs, inefficient spectrum policies, and local siting barriers can also contribute to the rural broadband deployment challenge.

The Accelerating Broadband Deployment Working Group has explored several areas of recommendations to promote the buildout of broadband infrastructure onto unserved and underserved agricultural lands, including for use in precision agriculture applications. These options include specific proposals related to leveraging underused infrastructure including spectrum, novel approaches to funding and incentivizing private investment, spectrum policies and license buildout, the efficient allocation of funds from USF and other government programs and streamlining permitting and equipping local officials with information and training. The proposals here adopt an "all-of-the-above" approach to the technology needs of precision agriculture, consistent with the prior

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[1] FCC Press Release; *Rosenworcel Announces Intent to Recharter Concluding Term of Precision Agriculture Task Force*; Aug 21, 2023 (available at https://docs.fcc.gov/public/attachments/DOC-396209A1.pdf).

[2] Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion; 2024 Section 706 Report; FCC 24-27, ¶ 61 (available at https://docs.fcc.gov/public/attachments/FCC-24-27A1.pdf).

[3] *Id.*

[4] *Id.* At ¶ 79.

recommendations of the Examining Current and Future Connectivity Demand Working Group. That Working Group noted that "achieving Precision Ag's full potential necessitates the widespread deployment of wired *and* wireless broadband connectivity to cover the last acre." Their most recent recommendations describe a dual-track process of deploying fiber as deeply as possible into rural areas, while promoting the deployment of wireless networks for "last acre" connectivity. Our policy recommendations below are divided into several groups:

Funding and Incentivizing Deployment to Unserved and Underserved Rural Areas and Precision Agriculture: Lawmakers and regulators have long recognized the inherent difficulty of deploying connectivity to rural America. The large geographic areas with low population density make the economics of deployment challenging without subsidies or other incentives. This Working Group has developed several recommendations to help address this issue, such as targeted funding to support precision agriculture and incentives for carriers to deploy in rural America such as spectrum auction bidding credits or tax incentives. In particular, the FCC's upcoming "5G Fund" should include dedicated funding to support precision agriculture.

Leveraging Underused Spectrum and Infrastructure: In addition to addressing some of the core economic issues above, agencies can help promote deployment by ensuring spectrum and other critical inputs are being used efficiently. Fiber, licensed fixed and mobile wireless, unlicensed wireless, and satellite services all have a role to play in the development of precision agriculture, and this Working Group has developed recommendations addressing all these technologies. One of the key recommendations is to promote greater rural wireless coverage through the use of geographic buildout requirements and other incentives. Agencies should also specifically consider the potential impact on precision agriculture as they develop policies relating to rapidly evolving satellite and unlicensed technologies.

Accelerating Deployment Through Improvements to Siting: Achieving the goal of universal broadband service throughout the United States will require billions of dollars of investment. Agencies and Congress can facilitate the rapid use of this investment by removing regulatory siting hurdles like unnecessary NEPA and NHPA rules that can slow deployment. We also recommend that permitting authorities, which will inevitably be taxed by the increased volume of projects that will flow from government investment, have the resources they need to complete their analyses in a timely and efficient manner.

An important component to deployment is the quality and reliability of broadband service. Undergirding many recommendations described below is the idea that our collective goal should be the deployment to unserved and underserved areas of *reliable* broadband service that meets specific performance metrics. Agencies should consider factors like upload and download speeds, reliability, and overall quality of service when considering new rules, policies, and programs.

Congress has an important role to play in ensuring the successful and timely deployment of broadband to rural America. While most of this Working Group's recommendations are targeted to regulatory agencies like the FCC and USDA, we encourage Congress to incorporate these ideas and priorities in future legislation. We also note several of our recommendations are predicated on the FCC's authority to hold spectrum auctions, which we hope will be reinstated soon. To the extent the charter for this Task Force expires at the end of this term, we hope it will be renewed in a future Farm Bill.

This Working Group congratulates the FCC, USDA, Congress and other government entities on their progress in promoting deployment of precision agriculture and acting on the Task Force's prior recommendations. We urge the appropriate agencies to seek public comment on this iteration of the Task Force's recommendations on an expedited basis to expand public awareness of these issues and encourage further discussion. By acting on these recommendations, government agencies can accelerate broadband deployment on unserved agricultural lands and promote the adoption of precision agriculture.

1) Funding and Incentivizing Deployment to Unserved and Underserved Rural Areas and for Precision Agriculture

One of the largest impediments to the accelerated deployment of precision agriculture and the related infrastructure is cost and the search for the economic resources necessary for rapid deployment. While the Federal government has made attempts to provide such resources through programs such as CAF II, RDOF, ReConnect, ARPA and now BEAD, none have or will address the entirety of the problem. It is also likely that no one tool or program will entirely address the issue. Therefore, it is necessary to develop and create a number of resources that can be utilized to accelerate and further the implementation of precision agriculture.

While the deployment of fiber has been and is the primary focus for all these programs, and it is by and large the costliest component in widespread adoption of precision agriculture, there are many other pieces to this puzzle. These include and are not limited to wireless infrastructure, i.e., towers, hardware associated with specific farming operations and software necessary to drive different farming applications. These are all capital intensive, and it is capital that is not available to most small to midsize farmers. Likewise, those companies that could deploy such tools and infrastructure are hesitant to do so because return on investment is perceived as being too low. The question then becomes, how do you encourage investment in such technology?

The answer may be in the form of financial incentives that promote investment in precision agriculture, just like financial tools have been used in other contexts (e.g., to stimulate economic development, facilitate renewable energy projects, and encourage the preservation and reuse of historical structures). Some of the financial incentives recommended here are not necessarily those that require Congress to find a pool of money from which to draw, like ARPA or BEAD, but rather through the use of tax incentives or other mechanisms that incent an entity to invest in the short term for long term gain.

1.1 Provide Financial Incentives for Further Build-Out

- The FCC and USDA should offer licensees and grant/loan recipients financial incentives to focus buildout on rural and agricultural lands. For example, the FCC could offer bidding credit and/or reduction in regulatory fees for providers that show proof of service to rural and/or agricultural lands.

- The FCC and USDA could also encourage Congress and state governments to offer tax incentives similar to those used to facilitate capital infrastructure improvements and investment in other forms of building communities. For example, state and federal programs offer investors tax credits and/or deferments for rehabilitating or repurposing historic buildings. Similar tools could be adopted or adapted to facilitate investment in rural broadband infrastructure and precision agriculture.

- Another example is found in Investment Tax Credits which have been used to promote investment in renewable energy capital projects. This provides companies with the ability to claim up to 30% of their capital costs in a project as an offset to their taxes. This stimulates the economy by allowing a company to invest in other projects through the tax credits they earn in addition to building infrastructure.

1.2 Fulfill Commitment to Support Precision Agriculture in Phase II of its 5G Fund.

- In designing its two-phased 5G Fund to support broadband deployment in rural America, the FCC recognized the importance of the Fund to the development of agricultural technologies and set aside $1 billion to be used in Phase II of the Fund for precision agriculture. The Commission explained that "dedicating *at least* $1 billion to this second phase of the 5G Fund will direct funds to networks supporting innovative agricultural solutions, increasing our nation's economic efficiency and encouraging economic growth in rural areas, especially in vast areas of agricultural lands that currently remain unserved."[5] The need for this targeted support in the country's most rural areas has only increased in the four years since that framework was adopted.

- However, in its recent 5G Fund Report and Order, the FCC elected to increase the budget for Phase I of the 5G Fund to up to $9 billion by reallocating the $1 billion that had been earmarked for Phase II precision agriculture support. The Commission now states it will "reassess" the 5G Fund Phase II budget following the conclusion of the Phase I auction.[6]

- The lack of adequate funding for broadband deployment in rural America remains one of the primary barriers to the development of precision agriculture. The FCC

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[5] *Establishing a 5G Fund for Rural America*; Report and Order; FCC 20-150, ¶31 (available at https://docs.fcc.gov/public/attachments/FCC-20-150A1.pdf).
[6] *Establishing a 5G Fund for Rural America*; Report and Order; FCC 24-89, ¶¶ 61-63 (available at https://docs.fcc.gov/public/attachments/FCC-24-89A1.pdf).

should therefore reinstate or even expand the amount set aside to support precision agriculture in Phase II of the 5G Fund.

1.3 Schedule 5G Fund Programs to Maximize Impact

- To ensure that the finite budget for the 5G Fund is used efficiently, the Commission should schedule the reverse auction to take advantage of the most up-to-date information regarding broadband deployments, including projects funded through BEAD and other infrastructure programs.

- NTIA's $42.45 billion BEAD program will bring both fiber and wireless broadband to currently unserved areas of the country, including rural agricultural areas. While BEAD is focused on funding fixed broadband services, much of the infrastructure from those projects can be leveraged for mobile 5G services.

- Fiber deployments funded by BEAD can provide backhaul for mobile wireless services, and traditional wireless antennas can collocate on new towers used for fixed wireless, thus reducing the CAPEX and OPEX needed for 5G Fund projects.

- Funding new mobile wireless projects now as part of the 5G Fund, without a complete picture of how BEAD projects could both redefine unserved areas and provide important inputs for future network deployments, would risk misallocating scarce resources.

- Overfunding certain projects would almost certainly result in underfunding the most rural, and expensive to serve, areas of our country (i.e., farmlands).

1.4 Create Targeted Subsidy Programs for Precision Agriculture

- Targeted subsidies are necessary for sparsely populated areas where it is difficult for service providers to justify the initial investment and ongoing operational costs to sustain broadband connectivity over time.

- In 2022, the Government Accountability Office released a report that cited broadband funding being allocated through 15 separate agencies and more than 130 separate programs.[7] In addition to the dedicated funds referenced in the 5G Fund recommendation above, all federal programs intended to fund broadband deployment should dedicate funds for precision agriculture. Such programs include, but are not limited to, USDA programs delivered through the Rural Utilities Service, Rural Development, and Natural Resources Conservation Service, FCC programs, and NTIA programs.

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[7] Government Accountability Office (GAO), *BROADBAND: National Strategy Needed to Guide Federal Efforts to Reduce Digital Divide*, GAO 22-104611, May 2022 (available at https://www.gao.gov/assets/gao-22-104611.pdf).

2) Promote Coordinated and Complementary Funding Between Programs, Including Combining Awards Where Appropriate and Necessary

The lead priority of funding should be to deliver broadband to unserved and underserved areas. As discussed above, there are many separate programs designed to fund broadband deployment projects in unserved and underserved locations, some of which could support precision agriculture. Given the similar goals of these programs, there is a significant risk that multiple programs could fund similar broadband deployment projects in the same area, potentially duplicating efforts and squandering limited resources.

To ensure responsible funding, agencies should enforce rules that make applicants or geographic areas receiving deployment subsidies from more than one source to document expenditures in each subsidy program. These expenditures should be subject to audit.

However, the most rural parts of the country that house many of America's farms and ranches are also among the most difficult and expensive areas to reach with broadband. This can put these areas at a disadvantage when competing for limited broadband funding resources; mechanisms used to award funding may select "winners" based on their comparative efficiency – the ability to deliver more service for a smaller investment. The perverse result is that the areas that most need broadband deployment subsidies can potentially be the areas least likely to receive them.

In certain cases of building middle mile and last mile service, the potential benefits from allowing program participants to combine multiple funding sources for a single project could outweigh the potential harms from duplicative funding and help overcome this cost barrier. By permitting project managers in such cases to responsibly combine funding from two or more sources, programs can promote deployment in the hardest-to-serve areas of our country that might not otherwise receive funding through traditional project scoring or reverse auction criteria.[8]

2.1 Establish Opportunity Zones in Unserved and Underserved Agricultural Areas

- Opportunity zones are an economic development tool that facilitates investment in distressed areas in the United States. As used today, their purpose is to spur economic growth and job creation in low-income communities while providing tax benefits to investors. All 50 states have areas designated as "opportunity

[8] At the request of one Working Group member, we note that the preceding paragraphs in section 2 of the Accelerating Broadband Deployment chapter of the Task Force's report reflects changes from the findings in the final Working Group report submitted to the Task Force.

zones," many of which are located in rural areas. These areas are generally designated in areas classified as "low-income." However, the legislation that created opportunity zones could be amended (or adapted) to instead designate areas based on factors besides income, such as the availability of broadband and whether a given area is unserved or underserved.

- The benefit that comes with investment within a qualified opportunity zone is in the form of a tax deferral on capital gains. There are numerous rules and qualifiers to use this tool. A similar mechanism could be developed or used to encourage investment in infrastructure, hardware, software, and applications that develop broadband capabilities to support precision agriculture.

2.2 Allow Cooperatively Owned Telecommunications Utilities to Qualify for Municipal Bonds

- Congress could review municipal bond criteria to possibly include funding of cooperatively owned rural telecommunications that deliver data and voice services to underserved and unserved areas.
- Cooperatives are representative units with boards of directors elected directly by the membership within the cooperative's territory. They are further governed by state and federal regulations and guidelines.
- Granting the ability for cooperatives to qualify for municipal bonds would stimulate private investment which finds the dual state and federal tax exemption on dividends attractive.

2.3 Explore Block Grants and/or Revolving Loan Fund Programs to Build Out Broadband to Support Precision Agriculture

- Block grants are another mechanism that could conceivably be adapted for such use.
- A downside could be the initial outlay of a block grant. However, that could be mitigated by establishing a revolving loan fund to augment precision agriculture buildout that is continually replenished.

2.4 Explore Tools Such as Tax Incremental Financing (TIF) Districts to Fund Precision Agriculture Buildout

- These are created at the local level with state enabling legislation, and while not an incentive in the strict definition of the word, they do allow for borrowing against the future real estate values in a designated geographic area. In a TIF district, plans are developed for specific improvements within the district. The TIF district borrows against the future increase in property tax revenues to fund public or private projects. The proceeds from the TIF can be used for a variety of purposes, such as: repaying bonds issued to cover project development costs, funding individual projects, attracting economic development projects, creating jobs, and fostering infrastructure investment.

- This is just an example of a possible tool to be used to further expand adoption of precision agriculture. Practical application of this mechanism would likely require some tweaking of definitions and requirements at the State level. As in the case of opportunity zones, adoption of such legislation could most likely occur quickly if there were consensus among the relevant parties to make this happen.

2.5 Adopt an All-of-the-Above Technology Approach for Current and Future Funding Programs

- Government entities should ensure that broadband funding mechanisms take a technology-neutral approach to maximize the reach of finite public funding.

- As the Connectivity Demands Working Group found in its last report, "[funding programs must be 'technology neutral,' incorporating all types of network infrastructure – fiber, wireless, [and] satellite." This requires a dual-track process of deploying fiber as deeply as feasible into rural areas, while promoting the deployment of wireless networks for "last acre" connectivity.

- Broadband funding programs should be created and managed with the recognition that many precision agriculture applications are inherently mobile and that reaching the "last acre" of agricultural land cannot be accomplished with fiber alone.

- As NTIA and the states make allocation decisions for the BEAD program, they should consider not only deployment costs and the speed of deployment, but also the technology needs of precision agriculture.

- Additionally, for those states with excess BEAD funds, states can consider using BEAD "non-deployment" funds for precision agriculture, including to create new "tower funds" that would support broader mobile wireless coverage in rural areas and farmland.

2.6 Facilitate the Emergence of Sustainable Competition

- FCC, NTIA, USDA, and State policies should support the emergence of sustainable competition over time and avoid erecting publicly funded barriers to market entry.

- Where physical infrastructure (*e.g.,* towers and other support structures, telecommunications conduit, dark fiber) is supported through the use of public funds, efforts should be made to evaluate whether shared use of such infrastructure by other service providers (including competitors) would be feasible. Such analysis should consider whether requiring the infrastructure owners/operator to allow such use would, on balance, enhance or undermine incentives to deploy such infrastructure (or broadband/precision agriculture facilities more generally) in the first instance.

3) Leveraging Underused Spectrum and Infrastructure

Delivering on the promise of precision agriculture will require the deployment of robust wireless networks. Our recommendations for spectrum rules and policies are grounded in core principles that the FCC and other federal agencies, such as the National Telecommunications and Information Administration (NTIA), have followed in attempting to promote broadband connectivity of all Americans. Those core principles are the following:

- Reliance on Wireless Infrastructure. Because many rural and sparsely populated communities in the United States have diverse topographical characteristics that present challenges for fiber optic broadband service, radiofrequency spectrum must be treated as an important infrastructure asset on par with fiber optics and the other more visible physical assets used to deploy affordable and reliable broadband service to Americans.

- Use of Multiple Assignment Mechanisms. The FCC has provided spectrum for commercial fixed and mobile use by employing several assignment methods such as auctioning exclusive use wireless licenses, deciding that some spectrum bands should include licensed-by-rule spectrum (at least 80 megahertz of spectrum in the 3.55-3.70 GHz band), and determining that some spectrum (e.g., 2.4 GHz, 5 GHz, 6 GHz, 57-71 GHz) should be unlicensed subject to the FCC's Part 15 rules. There is a need to assess if exclusive use licensed spectrum, allocated by FCC auctions, and unlicensed or licensed-by-rule spectrum is being effectively used to deploy reliable commercial wireless services to connect unserved and underserved communities in rural and sparsely populated areas.

- Focus on Reliability. In those areas where the commercial mobile and fixed wireless services are not reliable (frequent dropped calls or other wireless service disconnections), there is a need to assess what policies could improve reliability.

- Focus on Efficient Use of Spectrum. Where spectrum is not being used to deploy commercial wireless services to rural and sparsely populated areas, there is a need to assess what spectrum allocation and management policies (e.g., leasing of spectrum from licensees to other entities, geographic-based spectrum build-out requirements, other incentives) could be reasonably employed to promote more commercial wireless services in those areas.

Our recommendations also address how farms and rural areas take advantage of spectrum allocation and management policies that the FCC and NTIA have recently adopted to advance commercial wireless deployment for precision agriculture.

Some of the spectrum allocation and management rules and policies that we discuss in this report were recommended in prior reports from the Precision Agriculture Task Force and the Accelerating Broadband Deployment Working Group. While significant progress has been made on many of those prior spectrum allocation and management policy recommendations, we believe that some of our prior recommendations in this area should still be pursued by the FCC and NTIA. We recommend that the PATF and its working groups meet with the FCC and NTIA more often, and receive guidance from them, to facilitate this ongoing work in parallel.

3.1 Establish a Process for FCC and NTIA to Enact PATF Priorities

- To make progress on the other past spectrum recommendations from the PATF, there should be a process that allows the FCC and NTIA to provide guidance to PATF on setting spectrum policy priorities.

- The federal government has made commendable progress on several PATF spectrum recommendations, especially those that recognize low- and mid-band spectrum are critical for covering large areas.

- Feedback from the FCC and NTIA on spectrum recommendations will ensure that the work of the PATF and its working groups can be targeted to achievable spectrum allocation policies and rules.

3.2 Accelerate Development of Direct to Device (D2D)

- The FCC, on March 14, 2024, voted to approve supplemental coverage from space (SCS) rules authorizing wireless carriers to partner with satellite operators to provide direct satellite-to-smartphone communication using certain terrestrial mobile spectrum. This action, among other things, may aid in addressing mobile dead zones and benefit consumer devices as well as precision agriculture equipment. Such applications can already be provided using mobile-satellite service (MSS) spectrum.

- D2D technologies can leverage satellite connectivity to augment the capabilities of terrestrial networks—particularly in “not spots” and other underserved areas. These novel satellite technologies can also be particularly important for connectivity in the aftermath of natural disasters. The FCC should continue to work to enable D2D applications, while ensuring that D2D operations in bands allocated primarily to terrestrial networks (i.e., “IMT” bands) are carefully managed and constrained to avoid interference into existing terrestrial deployment and/or deterring future deployment.

3.3 Encourage Use of Unlicensed and Licensed-by-Rule Spectrum

- The FCC and NTIA should not discourage the use of networks that rely on unlicensed spectrum, such as 902 to 928 MHz, or licensed-by-rule spectrum, such as General Authorized Access (GAA) spectrum in the Citizen Broadband Radio Service (CBRS) band (3.55 to 3.70 GHz).

- Networks that rely on unlicensed spectrum have substantially evolved to be capable of high-speed reliable broadband service. Notably, testing of equipment that uses the unlicensed spectrum in the 6 GHz bands has reached hundreds of megabits per second download and upload speeds.

- In May 2023 and November 15, 2024, NTIA issued reports explaining how using CBRS GAA licensed-by-rule spectrum has been a success in demonstrating that commercial and federal operations can successfully share the same spectrum band and promote greater wireless broadband connectivity in rural and other hard to serve geographic areas.

- Networks using unlicensed and licensed-by-rule spectrum can complement networks that are using exclusively held spectrum licenses that companies can win at FCC spectrum auctions, including CBRS Priority Access Licenses.

3.4 Allocate Low Band Spectrum for Precision Agriculture

- The FCC should look at allocating more sub-1-GHz spectrum for modest-speed Internet-Of-Things use, such as a licensed version of LoRa with modestly higher power levels and coordinated, but not necessarily exclusive, channel allocations.

- This would be to avoid the higher noise levels on the current Industrial, Scientific, and Medical (ISM) band, and could be an overlay of land mobile radio frequencies. LoRa connections (Long range) are ideal for applications that transmit small chunks of data with low bit rates.

- The full 902-928 MHz band is currently available for unlicensed use. Some companies are using that unlicensed spectrum for precision agriculture uses. Pending before the FCC is a petition for rulemaking by NextNav that would reconfigure the Lower 900 MHz band and provide NextNav with a single, nationwide 15-megahertz flexible use license pursuant to a new band plan. This would not help development of technologies in this spectrum band for precision agriculture.

3.5 Catalog Underutilized Spectrum

- The FCC should look for existing spectrum under 6 GHz and especially under 2 GHz that is underutilized in rural areas, even if it is part of an existing geographic license that is mainly used in more densely populated areas.

- This might also be an overlay of an existing flexible-use (mobile) band, or possibly spectrum shared with federal users.

- This is the same rationale that motivated the FCC to Enhanced Competition Incentive Program. Wireless companies hold spectrum licenses that are likely underused.

- The effort could be supported in part by a spectrum use survey.

3.6 Incentives for Further Buildout After Initial License Term

- The FCC should incentivize further network deployment by wireless licensees after initial construction milestones have been satisfied. These further incentives should target incremental build-out of network infrastructure/coverage to rural and agricultural lands.

- The FCC's rules specify construction milestones that are evaluated at the end of a licensee's initial license term. Once those milestones are deemed satisfied, licensees are not explicitly required to expand network coverage, even though significant portions of the relevant geographic service area may remain underserved.

- The FCC can correct this gap by incentivizing licensees to continue their build-out after they have met initial milestones. For example, the FCC could offer a bidding credit and/or a reduction in regulatory fees for providers that show proof of service to rural and/or agricultural lands.

3.7 Incentivize Buildout of Cellular Base Stations and Other Wireless Infrastructure

- Agencies should consider opportunities to encourage the deployment of new wireless infrastructure.

- Government agencies should also provide incentives to carriers to mount their cellular base stations on existing towers, including real-time kinematic (RTK) towers through purchase or lease arrangements. The first step is taking inventory of existing assets, followed by marketing and incentivizing the use of the assets.

- Precision agriculture RTK towers have completed the permitting process for siting, which would reduce costs and enhance speed to market for wireless providers and cellular/mobile carriers.

- An inventory would include documenting the existing build specifications, backhaul, power supply, and who controls or owns the structure.

- Light Detection and Ranging (LiDAR) data can be used to identify existing vertical assets for the installation of middle-mile and last-mile solutions that connect end users (such as the farm or ranch headquarters) to an existing broadband backbone network. Grain silos, water towers, and other structures may have adequate lines of sight for network infrastructure.

- Incentives could also account for co-locating or sharing costs with other carriers on an existing tower. In some cases, such collocations or sharing may require upgrades to their existing power and backhaul, thus removing several barriers to rural and agricultural buildout by cellular/mobile carriers.

- This approach is not guaranteed to work in all locales because the provider's network design is a key consideration for network buildout.

- In future iterations of the Broadband Data Collection, the FCC should consider expanding the categories of data that carriers report, to potentially include service loads and other indicia of service quality and reliability at specific tower locations. Such reporting could help identify areas where additional towers may be needed to meet consumer demands.

3.8 Consider New "Rural" Service Rules

- When new spectrum become available for non-governmental (e.g., mobile) use, the FCC should consider whether it would be appropriate to adopt different allocations/service rules for urban and rural use.

- Urban use could be limited to other mobile bands (auctioned by geographic area but limited to areas where use is most likely) while in rural areas spectrum could be reserved for precision agriculture or other local, private uses.

- In future auctions, the FCC should adopt geographical license areas that encourage participation by smaller providers in rural areas.

- Encourage FCC to adopt spectrum allocation policies that particularly promote precision agriculture, e.g. bidding credits.

3.9 Use of Geographic-Based Buildout Requirements

- Going forward, the FCC should consider geographic- (rather than population-) based build-out requirements that incorporate strong incentives to serve rural agricultural areas.

- Population-based buildout requirements incentivize deployment in densely populated urban areas, potentially leaving rural agricultural areas without service. A shift to geographic-based requirements with a focus on rural agricultural areas could incentivize deployment to farms and make good on the FCC stated goal of "achieving reliable capabilities on 95 percent of agricultural land in the United States…."

- For example, the FCC could adopt an alternative requirement where a provider covers X% of agricultural areas in a way that supports precision agriculture in any license area that is considered more than Y% agricultural.

- The FCC should also consider expanding the availability of the "Rural Safe Harbor" but adjust its particulars to incentivize deployment to rural and agricultural lands.

4) **Incentivize Deployment of Currently Licensed Spectrum by Other Providers (formerly Partitioning unused/underused portions of licensed area)**

- Carriers that have met their build-out requirements but have not served rural/agricultural portions of their license areas by the end of the build-out period should be encouraged to allow other parties to use the spectrum to deploy service in rural and agricultural areas.

- Licensees that cede primary rural spectrum for deployment on farmlands, essentially partitioning at no charge, could be given some amount of bidding credit for use in future auctions, when they resume.

- The assignee or lessee should be required to provide service to the entire service area similar to the Enhanced Competition Incentives Program (ECIP) requirements. Certainty of use of the spectrum should be provided to the sublicensee.

4.1 Develop Test Beds for Private Networks

- The FCC and USDA should develop additional private network experimental areas, such as the Terranova Ranch example referenced in the 2023 Connectivity Needs working group report, to determine efficacy across a range of topographies and farm demographics.

- To deploy such a tool for one farm alone is cost prohibitive. Research is needed to determine how this technology can be made more cost-effective for small to mid-size farms.

- Part of the research would also identify operating structures in the form of “partnerships” between farming operations and the companies that design and implement such networks as well as agricultural retailers who would also benefit from the networks, or encourage the formation of “cooperatives” among a number of farms that would bring economies of scale to deployment of a private network in a given community

- A key obstacle to broadband deployment on rural and agricultural lands is the perceived lack of a viable business case for doing so (e.g., operators do not think the addressable market is large enough to allow them to recoup their capital and other investments in network deployment). Innovative business models may enable traditional and non-traditional operators to overcome this obstacle but may nevertheless be perceived as too risky to justify necessary investment. A targeted grant program could help to overcome this issue and establish that novel business models are workable in real-world situations—therefore making it easier for operators to leverage them on a non-supported basis.

5) **Accelerating Deployment Through Improvements to Siting**

Delivery on the promise of precision agriculture will require the deployment of robust wireless network and miles of fiber optic cable. But federal, state, and local siting requirements can, at times, stand in the way. Agencies should facilitate broadband deployment in rural areas by taking additional steps to reduce time-consuming and unnecessary regulatory obstacles to infrastructure sitting.

Below are some suggested reforms that could be made at the federal and state/local levels to facilitate expanded broadband deployment, especially on unserved agricultural land:

5.1 Equip Local Permitting Authorities

- Resources should be made available to these authorities to aid in this effort. This could come from the FCC, NTIA, or State authorities. This could take the form of training, funding to provide the necessary tools to process such applications in an expedited manner, or funding to hire outside consultants that have the expertise and ability to process these applications and plans in a timely manner that allows the infrastructure to be deployed as quickly as possible. Stated differently, no government policy should require rapid review and approval of permit applications without also providing the necessary support to local authorities to implement such policies.

- There has been much discussion about the time and burden permitting puts on the deployment of wireless infrastructure. Shot clocks and measures that are essentially pre-emptive in nature are often spoken of as a solution. While these are valid solutions, locals often feel that they are being bulldozed by the Federal government in the application of such measures to the point of resentment leading to these measures sometimes having the opposite effect desired.

- Federal policy should encourage local zoning authorities to review and update their ordinances making it easier to deploy wireless infrastructure in rural/agricultural areas. Historically, jurisdictions have “permitted” wireless infrastructure, i.e., towers in industrial areas. This was fine in the infancy of wireless network development. However, as demand, capacity, and technological needs have evolved, this is no longer workable as the need to improve coverage and capacity in ALL areas of a community has increased. At a minimum, infrastructure should be permitted in all rural/agricultural areas with minimum limitations.

5.2 Update National Environmental Policy Act/National Historic Preservation Act Implementation

- The FCC should update its rules and policies for implementing NEPA and NHPA, including the list of recognized “categorical exclusions” from environmental and/or historic preservation review, for deployments likely to benefit unserved agricultural lands.

- On May 1, 2024, the Council on Environmental Quality ("CEQ") published Final Rules revising its rules on environmental review procedures.

- Notably, the FCC has not updated its "categorical exclusions" for many years, and in 2022 the GAO recommended that the FCC review its NEPA rules and establish a process for doing so regularly in the future, which the FCC agreed to do.

- In updating its NEPA/NHPA rules and policies, the FCC should seek to advance sustainability goals while recognizing that unnecessarily lengthy environmental and historic preservation reviews may undermine broadband policy objectives (*e.g.,* delaying expansion efforts or increasing costs).

- In April 2024, NTIA adopted more than 30 categorical exclusions for projects that are likely to be involved with broadband deployment programs that Congress mandated NTIA to implement, including the Broadband Equity Access and Deployment (BEAD) program. The FCC, USDA, and other federal agencies with broadband deployment subsidy programs should review NTIA's 2024 categorical exclusions to see if it would be appropriate to implement those exclusions in non-NTIA programs.

5.3 Use Cost-Based Permitting/Fee

- The FCC should clarify that its cost-based fee standard applies beyond small cells and encourage state and local governments to adopt siting fee structures that incentivize rather than impede deployment (particularly in unserved agricultural areas).

- The FCC has said (interpreting Sections 253 and 332 of the Communications Act) that state/local siting fees cannot be greater than a reasonable approximation of the costs for processing applications and for managing right-of-way deployments, and it has identified specific fees for small deployments that presumably comply.

- Reducing fees for non-small cell deployments would help incentivize broadband providers to serve agricultural areas (and support precision agriculture) by making the deployment economics more attractive.

5.4 Develop Playbook for Deployment

- The FCC and USDA should work with non-profit organizations, trade associations, and other private parties to develop "playbooks" to guide deployment of precision agriculture connectivity solutions for various applications and use cases.

- Deployment of precision agriculture technologies in rural and agricultural areas may require specialized technical and business knowledge. Playbooks can help to disseminate this specialized knowledge and lower barriers to entry. The "playbooks" developed by the FCC and USDA should incorporate recommendations to ensure that broadband deployments on rural and agricultural lands are economically sustainable.

- Broadband deployments on rural and agricultural lands should be sustainable over time. Given budgetary limitations, it is not feasible for any funding mechanism to cover operational expenses on an ongoing basis. Playbooks developed by the FCC and USDA should focus on best practices to provide long-term sustainability.

- The "playbooks" developed by the FCC and USDA should incorporate recommendations to ensure that broadband deployments on rural and agricultural lands reflect best practices in terms of environmental sustainability.

APPENDIX: Working Group Membership

Chairman Heather Hampton+Knodle, Knodle, Ltd. Farms

Vice Chairman Jarrett Taubman, Viasat

Dave Crawford, T-Mobile

Louis Peraertz, Wireless Internet Service Providers Association

Matthew Peterson, National Grange

Carolyn Price, Upstate New York Towns Association

Dan Watermeier, Nebraska Public Service Commission

Douglas Weber, Urban Wireless Solutions, representing Ingham County, Michigan

APPENDIX: Sources

Chandler Vaughan, State of Virginia Office of Broadband
USDA NASS Technology Use by Farmers 2023

EXAMINING CURRENT AND FUTURE CONNECTIVITY DEMAND FOR PRECISION AGRICULTURE

Table of Contents

1. Executive Summary

Urgent Call for “Last Acre” Initiatives

Our Working Group strongly urges the swift adoption and implementation of “Last Acre” initiatives, policies, and incentives to deliver high-capacity broadband with symmetrical speeds of 100 Mbps and low latency (ideally below 10 milliseconds) across working lands. Achieving this level of connectivity is crucial for fully harnessing the potential of today’s advanced applications in Precision Agriculture, which are essential for food security, water conservation, reducing nutrient inputs, and enhancing food safety.

Optimal Infrastructure Scenario

The ideal infrastructure scenario involves extending fiber to the farm edge, specifically to a designated Broadband Service Location (BSL) on the FCC coverage map, where a mini data hub is installed. This model provides the necessary backbone to enable private 5G, 6G, and beyond, supporting core initiatives and on-farm Internet of Things (IoT) operations while ensuring sufficient throughput to handle the ever-growing volume of data, including AI-driven insights from the cloud.

Last-mile fiber to the farm is foundational for enabling advanced wireless technologies that can meet diverse coverage needs and facilitate broader cloud integration. This principle has been adopted by other countries, with China currently leading in fiber deployment.

The Role of Edge Computing and Cloud Connectivity

Both edge computing and cloud connectivity are essential components, functioning like two sides of a bridge that connect and deliver efficient data management and processing for Precision Agriculture.

Edge Computing: This technology reduces bandwidth and latency requirements for on-farm operations by processing data locally, close to where it is generated. This approach allows for real-time decision-making and quick responses to immediate needs, such as adjusting irrigation, deploying autonomous equipment, or addressing alerts related to crop health. Additionally, it provides secure, localized data storage to protect sensitive information and ensures continuity of farm operations during external network outages.

Cloud Connectivity: In contrast, the cloud offers significantly higher computing power for complex data analysis and large-scale processing. It enables “blink-of-an-eye” solutions by quickly aggregating and analyzing vast amounts of data from multiple sources—such as field-level microlocal weather forecasts, soil conditions, crop health sensors, and market trends. The cloud’s powerful algorithms, AI, and machine learning capabilities can identify patterns, generate predictive insights, and support actionable precision agriculture strategies, including optimizing planting schedules, managing risks, and maximizing yield.

Long-Range Planning with AI: AI-driven insights in the cloud facilitate long-range planning by integrating data over time to uncover new trends or potential challenges that may not be immediately apparent. For instance, analytics providers with permissioned access to producers' cloud-stored data can use AI to predict disease outbreaks, recommend the best crop varieties for specific microclimates, and help manage risk by considering years of data and diverse environmental variables. AI can also connect to broader networks, such as supply chains and market systems, enabling farms to react swiftly to changes in demand or price fluctuations.

Conclusion: By leveraging both edge computing for real-time, on-site decision-making and highly secured cloud connectivity for powerful, AI-enhanced analysis, this dual approach ensures that farms are equipped with the immediate responsiveness and strategic intelligence needed to optimize their operations and resources.

FCC Rural 5G Program

We recommend dedicating funding specifically to "Last Acre" programs, arguing that agriculture deserves the same priority as "anchor institutions." This is due to its vital role in food production, maintaining global competitiveness, ensuring rapid farm-to-fork traceability, and extending connectivity to surrounding farming communities. These communities, composed of the individuals who grow our food and their families, often lack access to broadband when funding programs are based on population density rather than geographic need.

BEAD Program

While it may seem late in the process, there is still an opportunity to incorporate a targeted solution. State broadband offices are currently designing complex infrastructure plans that require both financial prudence and creative thinking. This effort resembles a massive puzzle with many unique challenges, and a strategically placed 10-mile stretch of fiber to connect nearby cropland could be the perfect fit. According to data from December 2023, 96% of U.S. cropland is within ten miles of existing fiber infrastructure.[9]

This presents a significant opportunity for the NTIA to guide states in considering these proximity maps as an additional overlay in their planning processes, allowing them to identify feasible ways to intentionally include agriculture in their connectivity strategies.

A Once-in-a-Generation Opportunity

Together, these two programs represent a once-in-a-generation funding opportunity, as vital today as rural electrification was in the 1930s. The window to act is now. Equally important, all broadband funding initiatives must ensure that precision agriculture infrastructure—both equipment and software—are included as eligible expenses for reimbursement.

Technology is available; the goal is to secure timely government programs and incentives specifically for agriculture. This will help counterbalance the high cost of rural deployment

[9] Harry Crissy, Penn State; Rockefeller Foundation paper included as an appendix.

and provide farmers with the AI-driven tools they need to address climate change and a growing global population.

If we fail to act now, we risk placing the country at a significant global disadvantage, jeopardizing our competitiveness, food security, and leadership in agricultural innovation.

To secure our future, we must move swiftly and decisively.

2. Introduction

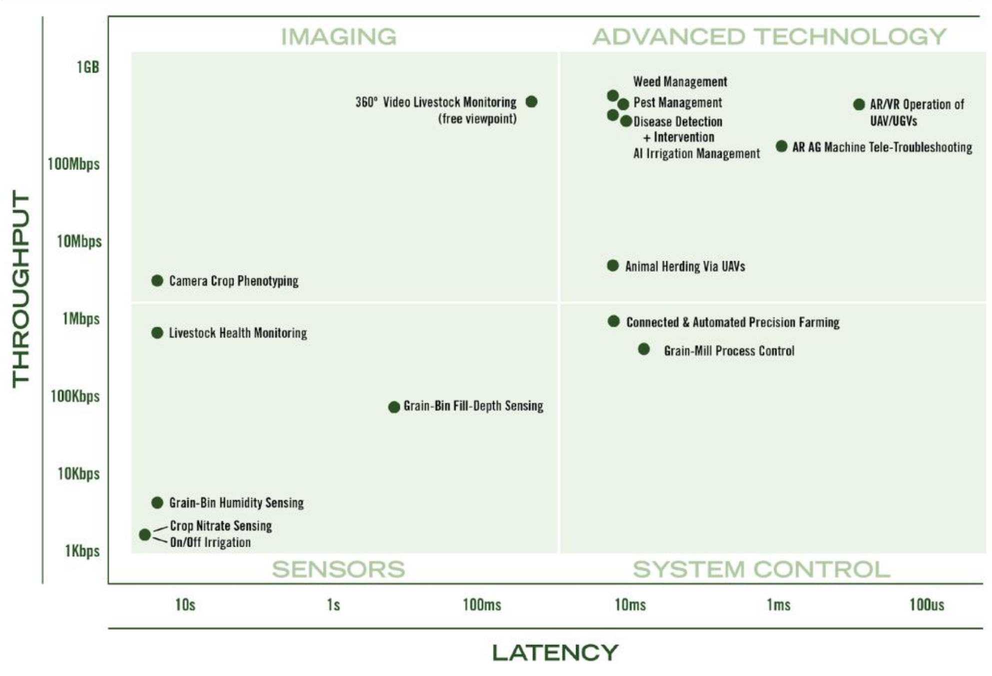
This report examines the evolving connectivity needs in Precision Agriculture by assessing current infrastructure, technological advancements, farmers' requirements, regulatory environments, and potential future developments. Together, these factors inform our recommendations for a focused, forward-looking connectivity strategy. Our recommendations are organized under eight key headings: Last Acre, Connectivity Requirements, Infrastructure, Spectrum, Funding, Standards, Redundancy, and Sustainability.

A. Last Acre

Our primary focus is on extending high-capacity internet service to cover croplands and animal operations, where internet access is crucial for integrating modern technologies such as IoT devices, autonomous machines, and farm-to-fork traceability systems. The goal of Last Acre connectivity is to ensure that every part of the farm is connected to the digital network, enabling real-time data collection, monitoring, and automation of farming processes. This level of connectivity is critical for improving efficiency, sustainability, and productivity in agriculture. Achieving this requires a policy and funding commitment to overcome high infrastructure costs and low population density. We advocate for a shift in government policies and programs from population-based criteria to an agricultural, geography-based approach that prioritizes Precision Agriculture.

B. Connectivity Requirements

Our proposed objective is to achieve a symmetrical bandwidth of 100 Mbps and latency targets below 10 milliseconds. This is the "sweet spot" for maximizing the transformative power of Precision Agriculture, transitioning from wide-area coverage to high-performing networks that support advanced technologies.



Source: *Hongwei Zhang, Richardson Professor ECE, Director WiCI, Iowa State University, and George Woodward, Trilogy Networks.*

Farmers can benefit from the fundamentals of Precision Agriculture—such as GPS-guided equipment, variable rate application technology, and field mapping software—at relatively low uplink speeds while still achieving highly desirable results. For instance, a pilot program at Terranova Ranch in Helm, CA, employs automated variable rate irrigation on 400 acres of tomatoes, successfully reducing water use by 10% with minimal bandwidth requirements.[10]

The potential benefits of higher throughput are transformative. By uploading the Terranova model to a secure cloud platform, it can be replicated and digitally tailored to suit a wide range of farms nationwide, scaling water savings across the country and turning a single proof of concept into a significant climate solution.

High-speed connectivity and advanced data processing are crucial for fully unlocking the potential of Precision Agriculture. At its core, Precision Agriculture thrives on the ability to collect vast amounts of data and convert it into actionable insights through powerful computational tools. This data-driven approach is poised to revolutionize farming, much like the tractor did in its time.

[10] Updated information from the use case featured in last term's report as the farm expanded the system from 80 to 400 acres.

In fact, thought leaders have coined a new adage: **“**Data is the new tractor**.”** Just as the tractor reshaped agriculture, data-driven decision-making is set to be equally transformative, enabling smarter, more sustainable farming practices, optimizing yields, and improving resource efficiency to meet global demands.

Lower latency is critical for enabling real-time decision-making, response, and execution. Specifically, low latency is safety-critical for autonomous trucks, with 10 milliseconds being ideal for real-time decisions under optimal conditions. Currently, 5G networks achieve latencies of 10 to 20 milliseconds, although latency can vary depending on factors such as network congestion, distance from the cell tower, and specific network configurations. Future 6G technology is expected to improve upon this. A latency of 10 milliseconds would allow trucks to communicate effectively in real time, facilitating interactions between autonomous grain carts and combines during harvest.

E2E Latency vs. Farming Efficiency and Cost

Max. E2E Latency	Max. Vehicle Speed for Inch-Accuracy Farming Operation
1 ms	57.15 MPH
3 ms	19.05 MPH
10 ms	5.715 MPH

Source: *Hongwei Zhang, Richardson Professor ECE, Director WiCI, Iowa State University.*

The key drivers for achieving these connectivity goals include deploying fiber to farm and ranch premises and incentivizing the targeted expansion of high-performance wireless connectivity. This approach aims to provide broad, umbrella-like coverage across the entire farm, free from line-of-sight restrictions.

Source: *AI-generated graphic*

We recommend deploying Last Mile fiber to cover the final stretch of delivering broadband services to the farm edge, coupled with Last Acre connectivity, which extends the network across the farm. This setup allows data-driven tools like sensors, drones, and automated machinery to rely on real-time internet access, optimizing farming operations.

Both Last Mile connectivity and Last Acre connectivity are crucial concepts for expanding internet access in agriculture. While they serve different purposes, they are inextricably linked: without strong Last Mile connections, there would be no foundation to extend internet access across the Last Acre. Together, they are essential for ensuring that rural communities and agriculture can thrive in the digital age.

Nota bene: It is remarkable how few data points are shown in the throughput/latency graph above, highlighting the scarcity of real-life examples of specific use cases. According to Hongwei Zhang, Director of the Center for Wireless, Communities, and Innovation (WiCI) at Iowa State University, the lack of robust on-farm connectivity limits the availability of real-world measurement data needed to inform effective policymaking. This creates a chicken-and-egg problem. Zhang suggests several activities to address this gap:

- Conduct advanced R&D in real-world living labs (e.g., ARA wireless living lab), involving collaboration between industry and academic leaders from the AgTech and wireless technology sectors.
- Implement large-scale pilots on diverse producer farms, utilizing technologies that have proven effective in R&D environments to further evaluate and refine these solutions.
- Facilitate the widespread adoption of these technologies across farms nationwide with federal and/or state subsidies where possible.
- Perform high-fidelity assessments of wireless networks deployed in rural areas as they expand, using tools like FLOTO (a University of Chicago-based data collection system that monitors real-life internet performance metrics such as speed and latency) to gain essential insights into improving connectivity.[11]

C. Infrastructure

A combination of fiber and wireless connectivity—cellular and satellite—is essential to provide both primary and failover capabilities that support Precision Agriculture operations, addressing national food safety and food security concerns.

Research from Penn State demonstrates that fiber-to-the-farm is achievable. Notably, 96.1% of all crops are located within 10 miles of existing fiber infrastructure, and 99.9% are within 25 miles. This proximity allows for the establishment of a fiber junction box and power source at a suitable location on the farm, serving as a mini IoT hub. This setup enables high-capacity private wireless connectivity for Precision Agriculture applications and supports Cloud/Edge computing for data-intensive processes. Fiber enhances the capabilities of 5G coverage by facilitating denser small cell clusters on mid-band frequencies. Additionally, fiber-to-the-field provides redundancy for wireless solutions, whether terrestrial or satellite, to cover farm fields or ranches. With greater capacity and a lifespan of 30 years, fiber is more future proof, often regarded as the gold standard in connectivity. It could prove to be as essential to agriculture as the ground itself.

[11] https://www.ece.iastate.edu/~hongwei/

Last Mile fiber connectivity delivers direct access to farm or ranch infrastructure, ensuring that on-farm Last Acre networks operate with the highest possible bandwidth. Covering the last 10 to 25 miles to the farm gate is crucial, especially given the current opportunities for once-in-a-generation funding.

Last Acre coverage requires an “all of the above” approach, incorporating public cellular infrastructure, Fixed Wireless Access (FWA), satellite networks, and private on-farm cellular networks, all utilizing 5G, 6G, and beyond. These technologies will support strong, widespread, and highly secure connectivity from farmlands and animal operations to Edge computing equipment and the Cloud. According to IoT4Ag, an engineering research center funded by the National Science Foundation, multiple networks may be necessary to effectively cover and manage the full breadth of a farm or ranch, mitigating risks to autonomous operations with failover networks.

Source: *AI-generated graphic.*

Here is an AI-generated rendering of a farm connected to fiber at the edge, with a wireless connectivity bubble covering cropland and operations. This visual illustrates the seamless integration of high-capacity connectivity needed across the entire farm to support Precision Agriculture.

Within that bubble, we advocate for tech neutrality. The infrastructure required for Precision Agriculture is an increasingly complex ecosystem of technologies essential for maintaining agricultural viability. This ecosystem includes key components designed to enhance farm connectivity and functionality, literally from the ground up.

Ground Truth Technology involves several key components that work together to provide valuable agricultural insights. Soil sensors perform soil analytics, offering critical data on soil health. Micro-local weather stations collect precise, localized weather data, aiding farmers in making informed decisions based on current conditions.

The **Last Acre Wireless** architecture connects the field to Cloud and Edge computing through various channels. Satellites, particularly Low Earth Orbit (LEO) satellites with cellular interoperability, play an increasingly vital role in communication. These LEO satellites are advancing rapidly and could potentially rival traditional cell towers. However, meeting the bandwidth requirements set by BEAD (100 Mbps download / 20 Mbps upload) necessitates launching tens of thousands of satellites into orbit. Currently, only one company has achieved this “critical mass.”

Terrestrial options include fiber infrastructure supporting fronthaul and backhaul, towers for 4G/LTE and 5G macro networks, FWA networks operated by Wireless Internet Service Providers (WISPs), and on-farm private cellular networks for comprehensive connectivity.

A highly secure cloud connectivity and edge computing platform is essential for storing, processing, and analyzing data. The cloud serves as a foundation for the development and innovation of applications and solutions. Meanwhile, the edge computing infrastructure extends these capabilities directly to the farm, reducing bandwidth demands and latency, enabling local processing, and enhancing security.

Source: *AI-generated graphic.*

We recommend adopting a “Technology Neutral” approach within the Last Acre to ensure that every tool in the technology toolbox is available for farming operations. This comprehensive systems approach is crucial for maintaining redundancy, allowing critical farm applications to continue functioning seamlessly even if GPS or cloud connectivity is interrupted. By leveraging a variety of technologies—including satellite, terrestrial, and edge computing—farms can maintain continuous and reliable operations, even in the event of disruptions in the Last Acre.

D. Spectrum

Spectrum, while not a physical asset like fiber-optic cables or cell towers, is a crucial component of the infrastructure that enables wireless communication systems, especially in agriculture. Ensuring sufficient spectrum for agricultural use is essential for farmers to adopt cutting-edge technologies that enhance efficiency and productivity. Precision Agriculture, in particular, requires access to both mid-band and low-band spectrum to fully leverage modern farming technologies.

We recommend adopting a two-band spectrum solution for Precision Agriculture, incorporating both mid-band and low-band spectrum to support the diverse connectivity needs of modern farming technologies.

Mid-band spectrum provides a balance between speed and coverage, making it essential for data-intensive applications such as drone-based imaging, real-time crop monitoring, AI-driven analytics, and autonomous machinery. These applications require high data throughput and low latency, for which upper mid-band spectrum (3-6 GHz) is ideal for optimal performance.

Low-band spectrum is critical for long-range coverage and overcoming obstacles like trees, hills, and dense crop canopies. It is particularly suited for IoT devices, such as soil sensors, livestock trackers, and weather stations, which do not require high data rates but need consistent and reliable connections over wide areas. These IoT devices are foundational for Precision Agriculture, collecting the data that drives decision-making on farms.

By combining both mid-band and low-band spectrum, Precision Agriculture can achieve high-speed data transmission and reliable, long-range connectivity. This dual-spectrum approach is vital for ensuring that farmers can fully utilize modern agricultural technologies. The key to success lies in creating hybrid networks, employing dynamic spectrum management, and ensuring dedicated government support.

Achieving a hybrid network that leverages both mid-band and low-band spectrum requires the integration of several technologies and strategic infrastructure planning:

- **Hardware Deployment**: Farms need close proximity to fiber front haul, radios, and antennas that support both mid-band (for high-speed applications) and low band (for long-range coverage). These stations can serve multiple applications depending on specific connectivity needs.

- **Edge Computing**: Incorporating edge computing allows data to be processed locally for time-sensitive applications, such as real-time crop monitoring or machinery control. AI can optimize data flow between mid-band and low-band tasks, improving network efficiency.

- **Dynamic Spectrum Sharing (DSS)**: DSS technology enables flexible use of both spectrum types, dynamically allocating bandwidth to applications as needed. This ensures efficient use of mid-band for bandwidth-heavy tasks and low-band for continuous IoT device connections.

- **Public and Private Networks**: A combination of public and private networks is essential. Public low-band networks (currently 4G/LTE and/or 5G) can support IoT devices across vast rural areas, while private cellular networks using mid-band spectrum can handle high-speed data transmission on the farm. This approach ensures secure, reliable connections while managing costs.

- **Network Management**: AI-driven network management software should be implemented to manage hybrid networks, dynamically switching between mid- and low-band spectrum based on application needs. This approach optimizes bandwidth allocation and ensures seamless connectivity.

Government support is critical to ensuring that Precision Agriculture has access to both mid-band and low-band spectrum. Several policy actions can facilitate this:

- **Spectrum Set-Asides**: Governments should allocate a dedicated portion of both mid- and low-band spectrum specifically for agricultural use during auctions or awards. This would guarantee access for farming operations and prioritize agriculture's unique needs.

- **Infrastructure Subsidies**: Initiatives should fund hybrid, on-farm network infrastructure, supporting the deployment of mid- and low-band spectrum to benefit Precision Agriculture.

- **Incentives for Spectrum Sharing**: Expanding initiatives like Citizens Broadband Radio Service (CBRS), which allows cost-effective shared use of mid-band spectrum, would lower costs for smaller farms. Encouraging shared use of low-band spectrum for IoT devices would further enhance Last Acre connectivity.

- **Use-It-or-Lose-It Policies**: Current public cellular license holders should be required to deploy spectrum in rural areas or risk losing their licenses. This mandate would prevent underutilization of both mid- and low-band spectrum, ensuring it benefits agricultural operations in underserved regions.

- **Public-Private Partnerships**: Collaboration between governments, broadband providers, and agricultural organizations should be encouraged to fund the infrastructure needed for hybrid networks, ensuring broad access to the spectrum and connectivity that farmers need.

Looking ahead, in addition to ensuring access to existing spectrum bands, we recommend considering a dedicated agricultural spectrum band. Such a band could provide greenfield opportunities for future technologies without the complexities of coordinating across multiple users.

The FCC, in conjunction with the NTIA, should issue a Notice of Inquiry (NOI) to explore which spectrum bands could be designated for agriculture, taking into account the potential impact on existing users.

Precision Agriculture's success depends on access to both mid-band and low-band spectrum, which together provide high-speed data transmission and reliable long-range coverage. Achieving this requires the deployment of hybrid networks, dynamic spectrum sharing, and effective network management. Government programs must prioritize agriculture in spectrum allocations, support infrastructure development, and incentivize spectrum sharing.

By combining technological innovation with dedicated policy support, Precision Agriculture can harness the full potential of modern connectivity, helping to increase yields, reduce costs, and close the digital divide.

E. Funding

We propose prioritizing Precision Agriculture within the FCC Rural 5G Program and the Broadband Equity, Access, and Deployment (BEAD) program, utilizing their existing budgeted disbursement mechanisms to fund initial infrastructure deployment. These two opportunities are the most immediately available vehicles.

As the FCC Rural 5G Program progresses, we urge an emphasis on enhancing connectivity across our vital agricultural lands. We suggest branding this initiative as the "Last Acre Program" to ensure that robust 5G, 6G, and beyond connectivity is ubiquitous across working lands. This will enable IoT and robotic technologies at scale, with fiber strategically deployed to facilitate a quick transition to next-generation cellular network technologies.

We strongly recommend that the FCC reinstate the $1 billion allotment for agriculture that was included in the 2020 program.

It is critical that funding be specifically directed to ensure rural agricultural operations receive the meaningful 5G connectivity necessary to fully implement precision farming technologies, which are vital for boosting productivity and sustainability in our nation's food production. Enhancing connectivity on farms is essential not only for supporting our farmers but, more importantly, for ensuring the safety, quality, and availability of food for the country.

We urge the NTIA to engage with state broadband offices and agriculture commissions to ensure that agricultural needs are fully considered and integrated into the final BEAD allocations. The available funding should prioritize extending fiber to on-farm Broadband Serviceable Locations (BSLs) to support Precision Agriculture initiatives, which are key to closing the digital divide in rural areas. We have a rare and time-sensitive opportunity to cover the last 10 to 25 miles to the farm edge, making the most of these once-in-a-generation funding opportunities.

Additionally, we recognize the need for sustainable funding to support ongoing maintenance and operation. Connectivity solutions must remain viable beyond the initial deployment and should not be tied to short-term grant opportunities. For example, BEAD funding could be utilized for deployment, while the Affordable Connectivity Program (ACP) or its replacement could support ongoing operations.

At some point, a new Farm Bill will emerge, presenting further opportunities for programs that can expand farm connectivity. The specific connectivity challenges faced by farms require more specialized solutions than traditional rural broadband efforts can provide.

A Precision Agriculture Connectivity Program or Farm Connectivity Framework under the USDA or FCC could offer grants or low-interest loans for deploying private networks tailored to the unique connectivity needs of farms. This program, in collaboration with the NTIA, would establish a specialized fund to address the specific demands of precision agriculture, which differ from those of traditional rural broadband initiatives.

The program would fund private Last Acre 4G/LTE, 5G, and satellite solutions, allowing farms to deploy custom networks based on their size, needs, and equipment. Administered under USDA's Rural Development Programs or alongside the FCC, states could apply for federal funding, such as the BEAD program, to target agricultural projects within their rural strategies.

Bespoke funding solutions could include grants for custom network design (e.g., a combination of low-band and mid-band spectrum-based 4G/LTE, 5G, and satellite). This flexible approach to farm connectivity would utilize a mix of spectrum bands and technologies, highlighting the adaptability of networks to various agricultural needs. Supported by state and federal funding, this initiative could create scalable, farm-specific network templates and provide farms with cloud-based platforms for real-time connectivity, AI analytics, and network management.

We recommend the establishment of a dedicated Precision Agriculture Connectivity Program under the USDA or FCC, in collaboration with the NTIA to address the distinct requirements of precision agriculture, which differ from traditional rural broadband expansion efforts. This program should offer grants and low-interest loans for deploying custom farm networks that address the unique connectivity needs of agriculture, ensuring access to Last Acre 4G/LTE, 5G, IoT, and satellite solutions.

Program Features

- **Support for Private Networks:** The program would support private networks, including Last Acre 4G/LTE, 5G, and satellite solutions, enabling farms to implement custom networks based on their size, equipment, and operational needs.

- **Federal Funding:** Administered through USDA's Rural Development Programs or in conjunction with the FCC, states could apply for federal funding, such as the BEAD program, targeting agricultural projects within their rural development strategies.

Bespoke Funding Solutions

- **Custom Network Designs:** Grants would be available for custom network designs, including combinations of low-band and mid-band spectrum-based 4G/LTE, 5G, and satellite connectivity, ensuring networks are adaptable to various agricultural needs.

- **Scalable Network Templates:** The creation of scalable, farm-specific network templates would integrate cloud-based platforms for real-time connectivity, AI-driven analytics, and efficient network management.

Smart Spectrum Management

- **Investment in Technologies:** Recommendations would be made for investing in smart spectrum management technologies to promote dynamic spectrum sharing and coexistence.

- **Efficient Spectrum Use:** Technologies such as cloud-based spectrum management, artificial intelligence, machine learning, and advanced antenna systems would be leveraged to enhance the efficient use of federal spectrum while mitigating the risk of degraded capabilities.

- **Farmer Control:** It is essential to ensure that farmers retain control over which technologies to deploy based on their specific needs.

Direct Reimbursement Program

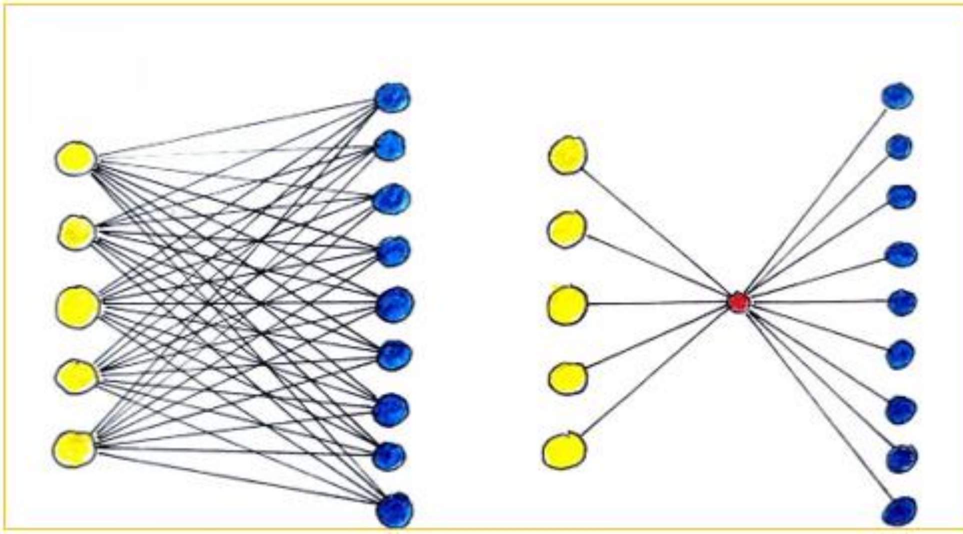
- **Two-Step Process:** This program for Precision Agriculture equipment, including private cellular network infrastructure, involves a straightforward two-step process:

  1. **Application:** Farmers submit an application outlining their needs based on factors such as crop type and acreage, with support from Land Grant and Extension personnel.

  2. **Voucher and Reimbursement:** Once approved, farmers receive a voucher to purchase the necessary Precision Agriculture equipment and can submit their receipts for reimbursement.

- **Encouraging Competition:** This approach fosters open competition among manufacturers, motivating them to provide the best products to attract farmer investments.

F. Standards and Interoperability in Precision Agriculture



Source: *Brent Kemp, President and CEO, AgGateway.*

We recommend encouraging and funding foundational work to develop standards, ontologies, and reference data repositories aimed at improving sensor and data interoperability.

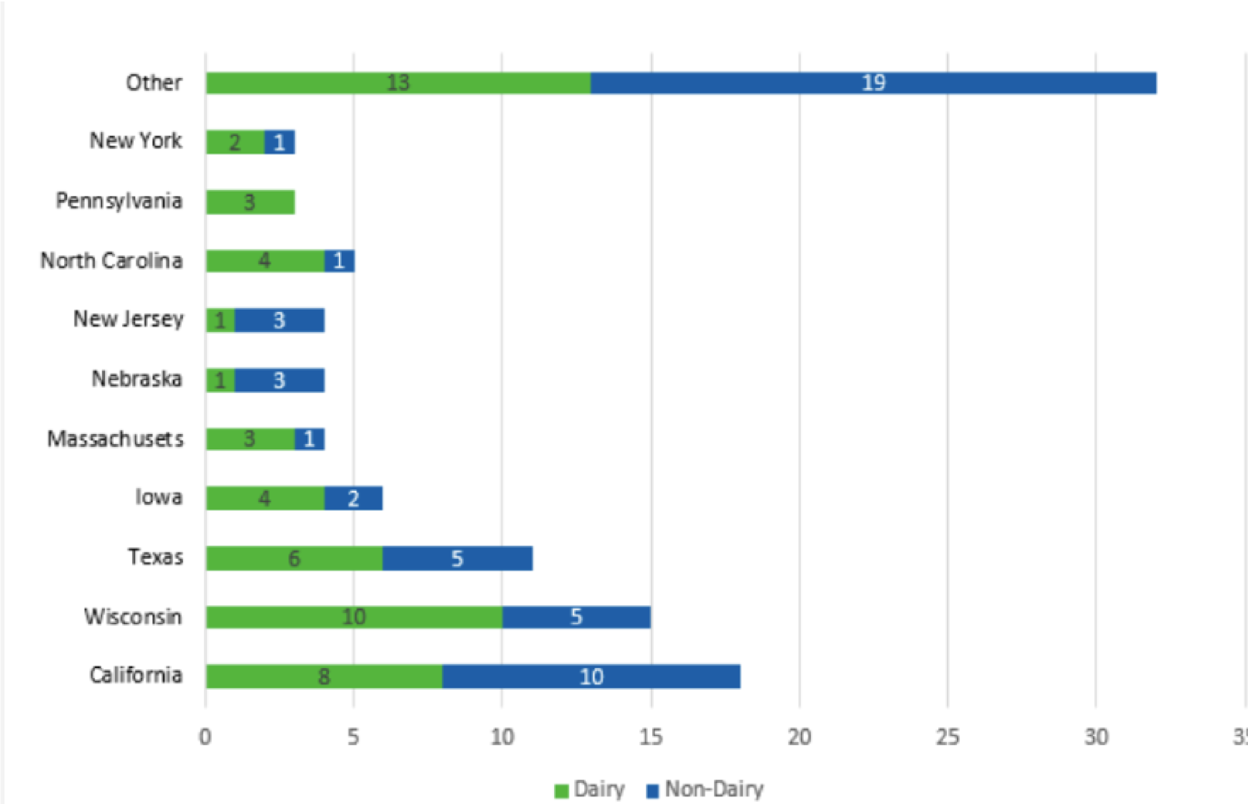
This is crucial for ensuring the quality, safety, and efficiency of agricultural systems and technologies. Enhanced interoperability fosters innovation simplifies compliance and traceability, and supports seamless global collaboration, enabling farms to operate more effectively. These efforts will drive scalability and enhance the ability to monitor and manage resources in real-time, ultimately advancing food safety and sustainability across the supply chain.

Where widely adopted industry standards already exist, they should be actively supported and promoted. Additionally, we recommend engaging with organizations such as the International Telecommunications Union (ITU), the Institute of Electrical and Electronics Engineers (IEEE), and the International Organization for Standardization (ISO). Participation in relevant technical committees and subcommittees will be essential. A coordinating committee within ISO exists to raise awareness and promote the implementation of applicable standards that span these organizations.

By avoiding unique requirements for device ecosystems, common standards pave the way for a more integrated and effective approach to Precision Agriculture. We aim to prevent proprietary or one-off technology solutions and instead support open standards over proprietary practices.

The U.S. must align with global standards to minimize the impending gap in Precision Agriculture equipment and applications compared to other countries. For instance, an analysis led by Daniel Foy of AgriGates LLC and Dr. Melissa Cantor of Penn State, focusing on the dairy industry, revealed a scarcity of Precision Agriculture companies and products in Pennsylvania relative to the size of the state’s overall agricultural marketplace.

State breakdown of Agri-Tech Companies within the United States



Source: *D. Foy, AgriGates LLC; M. Cantor Ph. D and A. Lee Department of Animal Science, Penn State.*

G. Redundancy

Redundancy is essential for mitigating unacceptable intermittent or lost signals, which can arise from various interferences, including extreme space weather events. For instance, the massive solar flare that occurred from May 10-12, 2024, disrupted GPS usage on farms, causing tractors to drive in circles and leaving some farmers unable to plant. According to news reports, this incident resulted in an estimated loss of $500 million in potential profits. Many will recall this event, as it also brought the Northern Lights as far south as Alabama.

While GPS is a powerful tool for location and navigation, it has several drawbacks. Addressing these shortcomings often requires the use of complementary technologies and the implementation of augmentation systems, essentially creating redundancy.

Edge computing plays a crucial role in this context, allowing local processing to continue even if connectivity to the central cloud is disrupted. This ensures that critical applications remain operational, safeguarding farm productivity.

In farming, anything can happen—and often does.

Photo credit: *New York Times.*

A competitive marketplace of service providers is essential for ensuring redundancy that encompasses all agricultural stakeholders. In an environment characterized by mergers, acquisitions, and shifting business focuses, it is crucial to avoid reliance on a single or limited set of connectivity providers.

We recommend prioritizing redundancy in farm connectivity and navigation systems to ensure continuous operation during disruptions.

This redundancy should include edge computing for local data processing and a diverse marketplace of service providers to prevent over-reliance on any single connectivity source. A robust, multi-layered system is vital for mitigating risks and safeguarding farm operations.

H. Sustainability

Sustainability in agriculture comprises three key components:

- **Sustainable Connectivity:** By definition, sustainable connectivity is robust, always-on, ubiquitous, redundant, and future-proof. As Ryan Krogh from John Deere aptly states, “We need as big a pipe as possible.” The increasing surge in data demands necessitates both expanded spectrum and infrastructure. Redundancy is critical to protect against various forms of interference.

- **Competitive Marketplace:** Another essential element of sustainability is fostering a healthy, competitive marketplace with multiple players. This diversity ensures resilience, innovation, and choice, particularly in light of the possibility that a supplier may change direction, face challenges, or be acquired by another company.

- **Environmental Impact of Satellite Launches:** Concerns have been raised regarding the environmental impact of increasing satellite launches, particularly Low Earth Orbit (LEO) satellites. Key issues include the growing risk of space debris and light pollution affecting astronomical observations. LEO satellites typically have a lifespan of about three years, depending on their altitude. They eventually re-enter Earth’s atmosphere and mostly burn up, creating a continuous need for new launches to replace aging satellites. This raises further environmental concerns regarding the frequency of launches and their impact on the atmosphere. In October, the California Coastal Commission denied a request to increase the number of rocket launches on the state's central coast, citing environmental concerns.[12]

- **Sustainability of Increasing AI use**: AI systems require vast amounts of electricity to power their computations. Cooling data centers that house AI operations rely on water-intensive cooling systems to maintain optimal temperatures. The combined energy and water use of AI can strain local utilities, increase carbon emissions, and contribute to resource scarcity, raising concerns that need to be addressed.

To support smart farming practices, it is essential to equip farmers with the connectivity required for precision agriculture technologies. These technologies create sustainable value by reducing inputs such as water, fertilizer, and pesticides. Additionally, robust connectivity is crucial for implementing effective farm-to-fork traceability systems, ensuring food safety and reliability, and supporting energy-efficient, longer-lasting mobile network equipment and IoT devices.

Achieving sustainability in agriculture involves two key strategies:

- **Cost Savings:** Reducing inputs and improving water management is vital, especially in states like California, where fields are being fallowed due to water shortages. Enhancing efficiency, minimizing downtime, increasing yields, and addressing labor shortages through automation are also critical. These efforts can help attract a younger generation interested in agricultural technology.

- **Tracking and Measurement:** A fundamental component of sustainability is effective tracking and measurement. In 2011, Congress enacted the Food Safety and Modernization Act (FSMA)[13] following widespread salmonellosis outbreaks traced to peppers and peanut butter. FSMA mandates food traceability from the field through packing, processing, and distribution.

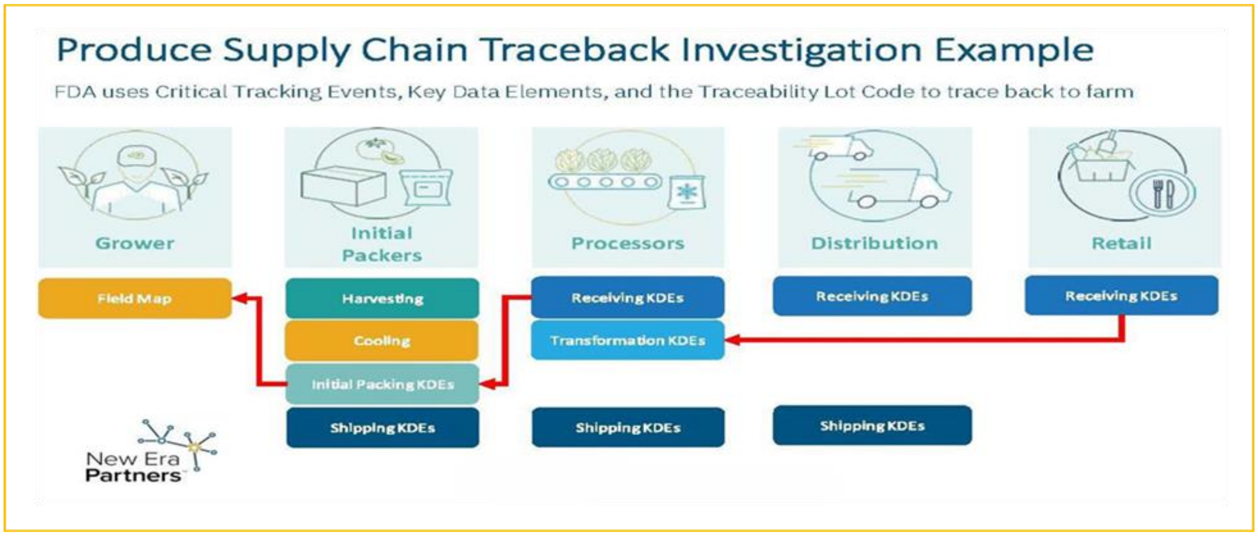
After a multi-year process, the FDA developed a final rule for FSMA in 2022 (the Food Traceability Rule), outlining specific recordkeeping requirements for foods identified on the Food Traceability List (FTL).[14] This rule will take effect on January 20, 2026. While the FDA's final rule aims to minimize the burden on small farmers by allowing manual "pen and paper" recordkeeping, there is a push towards electronic recordkeeping options for larger-scale operation.[15]

[12] https://www.latimes.com/california/story/2024-10-11/la-me-spacex-coastal-commission.

[13] https://www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/food-safety-modernization-act-fsma

[14] https://www.fda.gov/food/food-safety-modernization-act-fsma/food-traceability-list

[15] https://www.fda.gov/food/new-era-smarter-food-safety/new-era-smarter-food-safety-blueprint



Source: *Andrew Kennedy, New Era Partners*

Farm-to-Fork Traceability is imperative.

Fully transparent farm-to-fork traceability ensures that every stage of the food supply chain—from initial production in the field to the final point of sale—is clearly tracked, recorded, and accessible. This transparency allows all stakeholders, including consumers, to trace a product's journey and verify critical information such as:

- **Origin:** Details about where and how the food was grown or raised, including the specific farm or field.
- **Production Practices:** Information on farming methods, such as organic or sustainable practices, pesticide usage, and water management.
- **Harvest and Processing:** Records of when and how the product was harvested, processed, and packaged, including any handling or safety measures.
- **Transportation and Storage:** The path the product took through the distribution chain, including storage conditions, transportation methods, and distances traveled.

Quality and Safety: Documentation of temperature control, contamination testing, and any quality assurance steps taken to ensure food safety

Traceability data can be captured using lower-bandwidth connectivity, as it typically involves transmitting basic information like produce lot numbers, timestamps, and geographic locations. Notably, the FDA does not mandate specific technology for compliance; even a fax of a hand-drawn map is acceptable.

However, while minimal solutions may meet basic requirements, truly effective, precise, and transparent traceability—especially when aiming for real-time data and comprehensive insights—requires Last Acre connectivity. This ensures that data from every part of the farm, including remote or hard-to-reach areas, can be captured and transmitted seamlessly, enabling full traceability and a more responsive, efficient system. Fully transparent traceability guarantees that this data is accessible in real time, providing visibility and accountability throughout the entire supply chain. It allows consumers to verify the authenticity of claims (e.g., organic, fair trade), enables regulators to ensure compliance, and empowers producers to respond quickly to food safety issues or recalls. A major goal of the Food Traceability Rule is to reduce the time required to investigate foodborne illness outbreaks, such as E. coli, from 35 days to just five. Ideally, farmers, aided by technology—such as autonomous farm machines equipped with biosensors and detection technologies—will be able to detect and address outbreaks of E. coli or other pathogens in the field before crops are harvested or distributed.

Our findings underscore the urgent need for a targeted, sustainable, forward-thinking connectivity strategy to support agricultural innovation and resilience. We strongly recommend the enactment and implementation of Last Acre initiatives, policies, and incentives, highlighting their critical role in ensuring national security, particularly concerning food and water. The core objective is to extend high-capacity internet service to croplands and livestock operations.

We recommend prioritizing Last Acre connectivity to meet the growing demand for transparent food traceability.

Reliable, high-speed connectivity across every part of a farm is essential for tracking the entire production process—from field to consumer. Seamless data collection and sharing through IoT systems and smart technologies enable real-time monitoring of crops and livestock, enhancing transparency in how food is grown, harvested, and processed. This connectivity is vital for building consumer trust and meeting regulatory requirements for food safety and sustainability.

Our foundational recommendations for achieving the full potential of Precision Agriculture include:

- **Extending Coverage to the Last Acre:** Ensuring that every part of the farm has access to high-capacity internet.

- **Raising Connectivity Requirements:** Establishing higher standards for connectivity to support advanced agricultural technologies.

- **Building Resilient Infrastructure:** Developing infrastructure that can withstand disruptions and support continuous operations.

- **Leveraging Spectrum:** Utilizing available spectrum efficiently to enhance connectivity options.

- **Establishing Standards:** Creating industry standards that promote interoperability and reliability.

- **Ensuring Sustainability:** Focusing on sustainable practices that benefit both the environment and agricultural productivity.

The technology needed to transform agriculture is already available; the opportunity lies in securing the necessary funding and prioritizing Precision Agriculture within existing and future policies and programs.

3. Connectivity Needs Assessment

Today and into the Future

As consumers and stakeholders along the food chain, we increasingly expect farmers to provide detailed and transparent tracking of agricultural products from farm to fork. This entails clear information and insights about each step in the production process, including how crops are grown, what chemicals or nutrients are used, how animals are raised and processed, what is harvested and when, as well as the sustainability practices involved.

Farms are complex environments with numerous variables to manage, and tracking all critical data would be nearly impossible without a cost-effective, resilient system for data collection and analysis. Precision Agriculture simplifies this process, making it more manageable and accurate, while enabling us to trace the provenance of our food.

Reliable Last Acre connectivity is essential to Precision Agriculture. It empowers farmers to collect, analyze, and share data using various technologies, allowing seamless integration across their operations. Technologies such as sensors, GPS, drones, and automated machinery enable farmers to monitor soil conditions, track crop growth, and optimize water usage, all while generating the data necessary to trace the journey of food from field to table.

This technology-driven approach provides detailed insights into food production whether monitoring pesticide use, tracking animal welfare, or verifying sustainable farming practices. Without the connectivity and data integration that Precision Agriculture offers, farmers would struggle to meet the growing demand for transparency in food production.

This report outlines the current state of connectivity in agriculture and what is needed now and, in the future, to address the environmental, social, and economic factors that necessitate further developments in Precision Agriculture. Whether implementing detailed record-keeping to comply with nutrient management plans or adding autonomous harvesting robots to vineyards to address labor shortages, computer information systems and networks provide vital tools for our farmers.

The goal is to protect and strengthen our national food system, ensuring it continues to deliver high-quality products and increase yields. By enabling Precision Agriculture to the Last Acre, we can support a thriving, resilient food supply that meets growing demands while maintaining the standards that keep our food system sustainable.

We expect connectivity needs between the field and the farm office or data center to grow exponentially each year. As technology becomes more accessible and data demands evolve, stakeholders across the food chain will increasingly seek knowledge-driven insights. The solutions we propose will enable more effective use of data and technology, driving this transformation in agriculture.

Just as electricity was brought to farms through the establishment of government-led rural electric associations, Last Acre connectivity also requires government support and funding to bridge the gap that prevents many farms from accessing modern farming technologies. This assistance is crucial to ensuring that all farms benefit from advancements in connectivity and innovation.

We recommend that the FCC, in conjunction with the NTIA and USDA, prioritize funding and support for Last Acre connectivity. This will ensure that all farms can leverage Precision Agriculture technologies to meet the growing demands for transparency, sustainability, and productivity throughout the food supply chain.

Current State of Connectivity

While it is commonly believed that deploying fiber to farms (and/or enabling backhaul to radio spectrum networks) is impractical, new GIS analysis indicates that it may be much more feasible than previously thought. A national broadband mapping project at Penn State University, funded by The Rockefeller Foundation and utilizing data from December 2023, shows that 96% of U.S. cropland is within 10 miles of existing fiber infrastructure. Extending fiber to these areas could be achieved at relatively minimal cost while also covering unserved or unfunded broadband locations along the way.[16] Additionally, 99.9% of cropland currently lacking fiber optic service is within 25 miles of existing infrastructure. Although these areas are more challenging to connect to than those within 10 miles, they still represent a promising investment opportunity. Notably, two-thirds of the acreage within this 10 to 25-mile range falls within electric cooperative service areas, making these cooperatives likely partners in expanding connectivity with rights-of-way access and local service operations.[17]

These findings should encourage a focused effort to address connectivity gaps with fiber infrastructure. By doing so, we can fully realize the transformative potential of Precision Agriculture. Targeted deployment of fiber to farm premises can convert these sites into mini data centers that support Cloud and Edge Computing for data-intensive tasks. Additionally, strategically placing fiber at the Last Acre can enhance FWA transport, making mid-band connectivity a reality at the Last Acre. This approach would establish a

[16] See Appendix.

[17] GIS Specialist Harry Crissy, Pennsylvania State University

robust Last Acre ecosystem of high-capacity wireless technologies, enabling IoT systems to effectively manage core farm operations.

Fiber-to-the-farm perimeter provides the most reliable backup for both terrestrial and satellite wireless solutions used across farms and ranches. Fiber will densify 5G radio placement for robust mid-band coverage and accelerate the transition to 6G and beyond.

And, with a lifespan of 30 years, fiber is a more “future-proof” solution.

We recommend integrating fiber with edge computing resources to create high-speed connections to cloud services, enhancing data throughput and processing. This setup will enable a robust ecosystem of wireless technologies that support IoT devices for farm management, with satellite technology serving as a backup to ensure continuous connectivity in case of disruptions.

Beyond the gold standard of fiber connectivity, satellite communication is evolving to provide bridging solutions for remote and mobile applications. These technologies offer much-needed network redundancy in the event of a natural disaster.

Starlink’s ongoing satellite deployment is approaching the ability to meet the BEAD requirement of 100/20 Mbps bandwidth, although performance may diminish as the number of users increases.

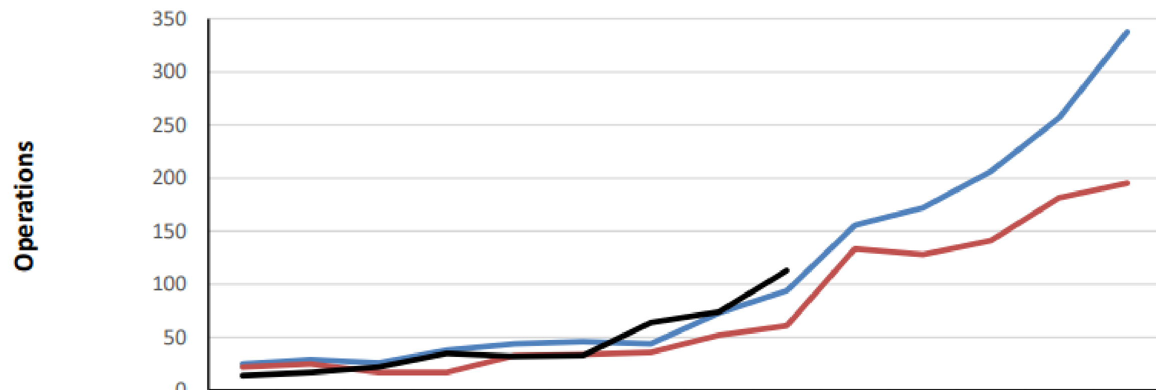
To boost throughput, the FCC has awarded spectrum for Low Earth Orbit (LEO) satellites, and Congress recently passed the Launch Communications Act, signed by the President in September, aimed at accelerating satellite launches. Achieving the target of 100 Mbps uplink speeds is contingent upon the expansion of the satellite constellation.

Of the more than 100 launches authorized by the Federal Aviation Administration this year, 91 have been SpaceX launches, with 62 dedicated to deploying Starlink satellites. Each launch typically delivers about 20 LEO satellites into orbit.

The FAA anticipates that private space launches will more than double in the next four years. According to its forecast, the Administration could approve up to 338 commercial launches annually by 2028. This surge in launches reflects the urgent need for an updated regulatory framework.[18]

[18] Broadband Breakfast Live October 9, 2024 - Democratizing Spectrum Access https://broadbandbreakfast.com/broadband-breakfast-on-october-9-2024-democratizing-spectrum-access/

FAA's Authorized Operations Forecasts



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Forecast High	25	29	26	38	44	46	44	73	94	156	172	206	257	338
Forecast Low	22	25	17	17	33	34	36	52	61	134	128	141	181	195
Actual	14	17	22	35	32	33	64	74	113					

Source: *This chart illustrates the steady increase in actual FAA-authorized commercial space operations from 2015 to 2023, along with the FAA's high and low forecasts for operations through 2028. Taken from the FAA Office of Commercial Space Transportation's Aerospace Forecast Fiscal Years 2024–2044.*

Meanwhile, John Deere and Starlink have established a partnership to integrate Starlink's satellite internet service with John Deere's agricultural equipment and technology solutions. By incorporating Starlink terminals into its autonomous tractors, combines, and other agricultural machinery, John Deere aims to enable faster and more reliable data transmission between its smart agricultural equipment and cloud-based platforms. This integration has the potential to facilitate seamless data flow from the field to cloud-based management systems, allowing farmers to make data-driven decisions in real-time and support remote diagnostics and over-the-air software updates, which require reliable, high-speed internet access.

While this technology aims to improve connectivity and data usage, its effectiveness depends on factors such as network reliability and the successful deployment of supporting infrastructure. As a result, satellite internet is a promising solution but is not yet fully capable of addressing whole-farm connectivity challenges, particularly in areas requiring real-time data for Precision Agriculture. To fully resolve these challenges, a combination of technologies is needed—specifically, hybrid systems that integrate satellite links with terrestrial infrastructure such as fixed wireless, fiber, or cellular networks.

In addition to satellite solutions, other technologies are advancing to play a crucial role in enhancing farm connectivity. FWA is one such technology, with companies like Ericsson investing in its potential to shape a post-BEAD landscape. While it may not fully replace fiber in terms of speed and reliability, its rapid deployment and cost-effectiveness make it a complementary solution for extending coverage. Many leading service providers favor

FWA because it aligns with a broader strategy of expanding 5G across their market areas and serves as a practical solution to potential shortages and rising costs of fiber construction. 5G FWA networks have the potential to reach 8.4 million rural households, or approximately 43% of rural households,[19] thereby lowering costs to expand coverage to nearby last acreage.

The Role of Edge Computing in Precision Agriculture

The role of edge computing has expanded dramatically over the past year. What was once considered visionary or cutting-edge has now become a prevailing trend in Precision Agriculture. Its key functions include reducing latency, bringing a portion of the cloud directly to the farm, and, importantly, protecting farmers' data. Another advantage of edge computing is its flexibility; it can be deployed anywhere, be it embedded in a combine, installed on an irrigation pivot, or set up in a mini data center, ideally at a fiber juncture.

Connecting edge devices to the cloud requires meeting several critical needs to ensure efficient, reliable, and secure data transfer. These requirements include sufficient bandwidth for data transfer, low and consistent latency, reliability through resilience and built-in redundancy, and strong security measures to protect against system failures, data loss, or data compromise.

Cost issues must also be addressed, ideally through government funding and grants that provide incentives, mitigate financial burdens, and offer crucial resources such as technical expertise, network design, training, and ongoing support services. An alternative approach is to advance public/private partnerships, like the recent joint venture announcement between Ericsson, T-Mobile, Verizon, and others, aimed at expanding digitalization by giving developers access to advanced 5G network capabilities.

Spectrum scarcity is another key barrier to advancing Precision Agriculture. While urban areas benefit from a concentration of infrastructure and available spectrum, rural America often faces shortages because telecom companies acquire licenses for broad areas without developing the necessary infrastructure in sparsely populated regions. This results in a situation where spectrum is technically allocated but remains underutilized due to incomplete infrastructure.

We strongly recommend that government programs and spectrum awards prioritize agriculture's specific requirements to ensure farmers can fully benefit from advances in precision farming. Ensuring that enough spectrum is allocated for agricultural uses is critical.

The 5G Rural Fund and Its Impact on Precision Agriculture

The 5G Rural Fund includes up to $900 million in incentives for incorporating Open Radio Access Network technology (Open RAN), which allows for dynamic and more efficient spectrum management. This is an important piece of the puzzle. Open RAN can facilitate

[19] Accenture study commissioned by CTIA, "5G Fixed Wireless Broadband: Helping Close the Digital Divide in Rural America".

the deployment of 5G networks at a lower cost by using interoperable equipment. However, this is only one part of the broader effort to close the digital divide in rural areas.

We strongly urge the FCC to reinstate the $1 billion allotment for agriculture that was originally included in the 2020 program. The lack of substantial 5G connectivity for U.S. farms highlights a missed opportunity to advance precision agriculture, which is critical for improving productivity and sustainability. Redirecting this funding is essential to ensure that rural agricultural operations can implement the full suite of precision farming technologies. These tools are vital not only for economic growth but also for meeting the increasing demands of a sustainable food system.

Comprehensive solutions include extending fiber networks to farm premises, encouraging dynamic spectrum sharing, ensuring access to both low- and mid-band spectrums, promoting private cellular networking ecosystems at the Last Acre, and addressing the challenges of unutilized spectrum and funding.

Dynamic Spectrum Sharing (DSS) holds significant potential for improving connectivity in Precision Agriculture, particularly in rural areas where spectrum is scarce. While it is still in the early stages of adoption for agriculture-specific use cases, DSS could enable more efficient use of both 4G/LTE and 5G networks to power the connected devices essential to modern farming. However, much broader deployment of 5G in rural areas will be necessary before its full benefits can be realized in the agricultural sector.

As of 2024, 6G wireless technology is in its early stages of research and standardization, with full deployment expected by 2030 and some early commercial applications anticipated by 2028.

6G is projected to deliver speeds up to 100 times faster than 5G and ultra-low latency, making real-time applications even more seamless with greater energy efficiency. Unlike 5G, which uses millimeter waves, 6G will operate on terahertz frequencies, enabling far greater data transmission but requiring breakthroughs in infrastructure due to shorter range and higher susceptibility to interference. Significant challenges include developing devices for terahertz frequencies, improving energy efficiency, and addressing global security standards.

The Next Generation of Networks

This next generation of networks will rely heavily on artificial intelligence (AI) and edge computing to manage data traffic, optimize network performance, and support autonomous systems. It will also enable immersive technologies like augmented reality (AR), virtual reality (VR), and mixed reality (MR) at unprecedented levels. Both public and private 6G networks will accelerate the advancement of use cases on the farm, supported by public and private sector stakeholders.

Countries such as the U.S., China, South Korea, Japan, and the EU are heavily investing in 6G technology, and the U.S. should aim to lead in leveraging this innovation to support our food system from end to end. However, for U.S. farmers, the benefits of 6G will remain limited—or even inaccessible—until the pervasive issue of cellular dead zones is addressed.

While 6G promises faster speeds, lower latency, and more advanced capabilities than 5G, it will still depend on a robust infrastructure. Without addressing these dead zones, farmers in rural areas won't be able to fully access or benefit from the connectivity advancements that 6G offers. Much like with 5G, improving rural cellular coverage is a crucial step in unlocking the full potential of both current and future technologies.

Regulatory Environment

The regulatory landscape for precision agriculture in the U.S. is evolving rapidly in some areas while remaining stalled in others.

First, the FCC's spectrum auction authority, which allows the agency to sell licenses for spectrum use, expired in March 2023 and has not yet been reinstated.

In response, the FCC is actively exploring alternative methods, such as utilizing Special Temporary Authority (STA) to temporarily grant spectrum access and examining "Inventory Spectrum" for public use. While these workarounds help mitigate the impact, they are seen as less effective compared to the long-term stability provided by auction authority.

That said, as dynamic spectrum sharing becomes more widely embraced, current regulatory frameworks that rely on static allocations may become outdated. AI-driven models could prompt new regulatory rules—now under study by the NTIA—to accommodate more flexible, automated, and efficient use of the radio spectrum.

One analogy is a highway: we manage to change lanes to get around traffic unless it becomes too congested. Now, imagine if one whole lane were licensed and unavailable to anyone else, even just to pass.

The NTIA is in the early stages of implementing the National Spectrum Strategy (NSS), introduced in November 2023. This strategy outlines key steps to ensure U.S. leadership in wireless technologies and improve spectrum management. It identifies over 2,700 MHz of spectrum for study and potential repurposing, with the goal of supporting technologies like 5G, satellite communications, and IoT—which are right in Precision Ag's wheelhouse.

The strategy emphasizes creating a spectrum pipeline to meet near-term and future demands and encourages the development of dynamic spectrum sharing technologies. It also highlights the importance of interagency coordination and introduces new initiatives for long-term planning, collaborative spectrum use, and transparent allocation processes.

Implementation and Regulatory Developments

Implementation involves several phases, including stakeholder meetings that began in September 2024, and studying specific spectrum bands like 3.1-3.45 GHz, which could be crucial for rural 5G deployments. Their multi-phase strategy is expected to develop over several years.

We strongly recommend that the National Spectrum Strategy (NSS) prioritize agriculture as a key pillar, ensuring that this critical sector is fully supported

through dynamic spectrum sharing and future spectrum policies to boost productivity in one of the nation's most essential industries.

In March 2024, the FCC redefined broadband as 100/20 Mbps. We advocate for raising the standards to 100/100 Mbps capacity to meet the demands of modern agriculture.

The FCC has also made two major regulatory moves in satellite communications:

- **Satellite-to-Cell Coverage Framework**: The FCC created a regulatory framework authorizing satellite operators to collaborate with wireless carriers to provide direct satellite-to-cell communications using certain mobile spectrum. This framework is expected to improve mobile phone operations and emergency services, especially in rural areas. It is significant for Precision Agriculture as it demonstrates confidence in the increasing capabilities of satellite connectivity.

- **LEO Satellite Spectrum Access**: The FCC has expanded spectrum access in the 2025-2110 MHz and 2200-2290 MHz bands to support the rapid growth of low-Earth orbit (LEO) satellite networks for broadband services. These changes include streamlining the processes for commercial space launches, allowing LEO operators to access the required spectrum more efficiently. Amazon faces an FCC deadline to have half of the 3,232-satellite constellation launched by July 2026. The throughput for satellite broadband is directly related to the number of satellites deployed.

Further regulatory considerations are underway regarding spectrum sharing and interference management between different LEO operators. To that end, the FCC recently created the Space Bureau, tasked with addressing issues related to satellite operations, space debris mitigation, and ensuring sustainable space activities. This department aims to improve the management of the growing number of LEO satellites and minimize risks associated with collisions and debris in space.

Rural 5G Fund

The FCC's revived Rural 5G program provides up to $900 million in incentives for integrating Open RAN technology, enabling more efficient and flexible spectrum management. This initiative would greatly benefit agriculture by reducing the cost of deploying networks and helping independent farms access wireless connectivity using mid- and low-band spectrum.

The program can support shared spectrum models, such as CBRS, where spectrum can be dynamically allocated among different users. For agriculture, this opens opportunities to access spectrum without requiring exclusive ownership, thereby lowering costs with spectrum that is already commercial but has limited deployment in rural counties.

- **Interoperability**: The program promotes interoperability between different vendors and technologies, ensuring that agriculture-based IoT devices and networks can operate smoothly across various spectrum bands and network types. This improves reliability and connectivity in rural areas.

- **Antenna Upgrades**: There is a strong focus on upgrading and boosting antenna signals. This initiative supports the enhancement of existing antennas and the deployment of new ones to improve signal strength and expand coverage. It also promotes the use of technologies like Open RAN, which can increase antenna power during peak times or in areas with weak signals. This allows for more efficient power management at antenna sites, reducing the need for major infrastructure expansions while still improving network capability.

- **Simplified Regulations**: The agency has revised its rules for attaching antennas and small cell infrastructure to existing utility poles, simplifying the process and enabling carriers to increase antenna installations in rural areas without the need to build new towers.

- **Power Limits Review**: The FCC is reviewing power limits for wireless devices and onboard units to allow higher transmission power where needed.

- **CBRS Power Thresholds**: Finally, the FCC is being urged to raise power thresholds for CBRS devices to improve outdoor deployments, expanding network coverage and performance for rural broadband and Precision Agriculture. Higher power would enhance the integration of CBRS with adjacent frequency bands, leading to better network performance and broader connectivity options.

In conclusion, we strongly recommend that the FCC specifically earmark Rural 5G funding for precision agriculture.

Congressional Initiatives to Improve Broadband Access for Agriculture

Several congressional initiatives aim to enhance broadband access for agriculture:

- **Launch Communications Act**: Signed into law in September 2024, this act builds on the FCC's previous actions by mandating that critical spectrum frequencies be allocated for commercial space launches, thereby reducing the need for special temporary authority for each launch.

- **U.S. Farm Bill**: The Farm Bill is currently in limbo following the expiration of the one-year extension of the 2018 Farm Bill on September 30, 2024. Ongoing bipartisan discussions include provisions related to broadband expansion, though it remains uncertain whether a full bill will pass before the year's end.

- **LAST ACRE Act**: This bipartisan bill proposes a competitive grant and loan program to expand high-speed broadband access to farms and ranches, facilitating the adoption of precision agriculture technologies in rural areas. The bill is currently still in committee.

- **Rural Broadband Modernization Act (H.R.3964)**: Introduced in June 2023, this bill seeks to improve rural broadband speeds by mandating a minimum symmetrical bandwidth of 100 Mbps. It is still in the early stages of the legislative process.

- **Spectrum Pipeline Act of 2024**: Introduced by Senators Ted Cruz, John Thune, and Marsha Blackburn, this act aims to restore the FCC's authority to auction spectrum and reallocate at least 2,500 MHz of underutilized mid-band spectrum for commercial use within five years. The bill is currently in the early stages of the legislative process.

- **Spectrum and National Security Act of 2024**: Led by Senator Maria Cantwell, this bill prioritizes balancing spectrum needs for both commercial and national security uses, emphasizing spectrum sharing and improving coordination between federal and non-federal users. It would also provide $7 billion to sustain the Affordable Connectivity Program (ACP). The bill is currently facing delays in the legislative process due to concerns about balancing the spectrum needs of commercial use and the Department of Defense (DOD).

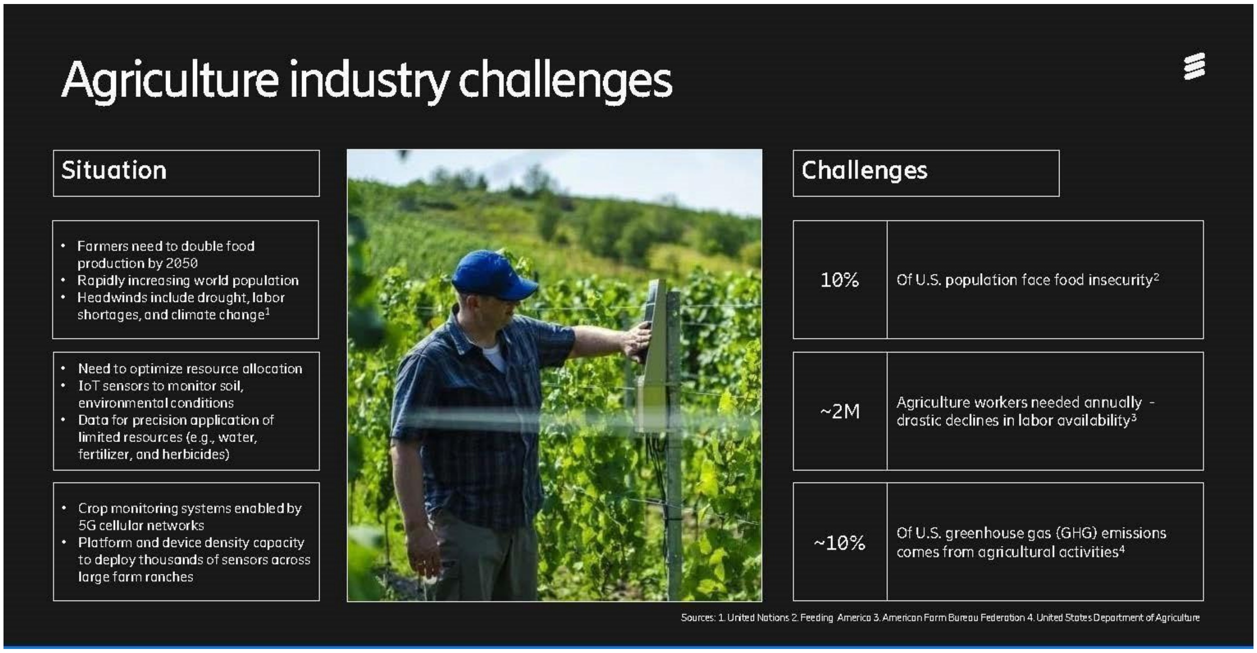
- **Affordable Connectivity Program (ACP)**: The ACP officially ran out of federal funding on June 1, 2024, leaving millions of households without critical internet subsidies. The future of the program remains uncertain, as ongoing political debates and funding challenges continue to delay its reinstatement.

Additionally, regulations focusing on sustainability, climate change, cybersecurity, artificial intelligence, and autonomous equipment—such as drones—are expected to see further development, particularly as Precision Agriculture technologies become more widespread and essential for meeting climate goals.

The Farmers' Perspective

Farmers face enormous pressure to double food production by 2050 to meet the demands of a growing global population. The obstacles they encounter include drought, labor shortages, climate change, and disruptions caused by natural disasters. These challenges are compounded by the fact that 10% of the U.S. population experiences food insecurity, and approximately 2 million agricultural workers are needed annually, with a noticeable decline in labor availability. Moreover, agriculture accounts for around 10% of U.S. greenhouse gas emissions.

Precision Agriculture, bolstered by emerging technologies, is essential for overcoming these hurdles. However, these advancements must align with the on-the-ground needs of farmers to be truly effective.

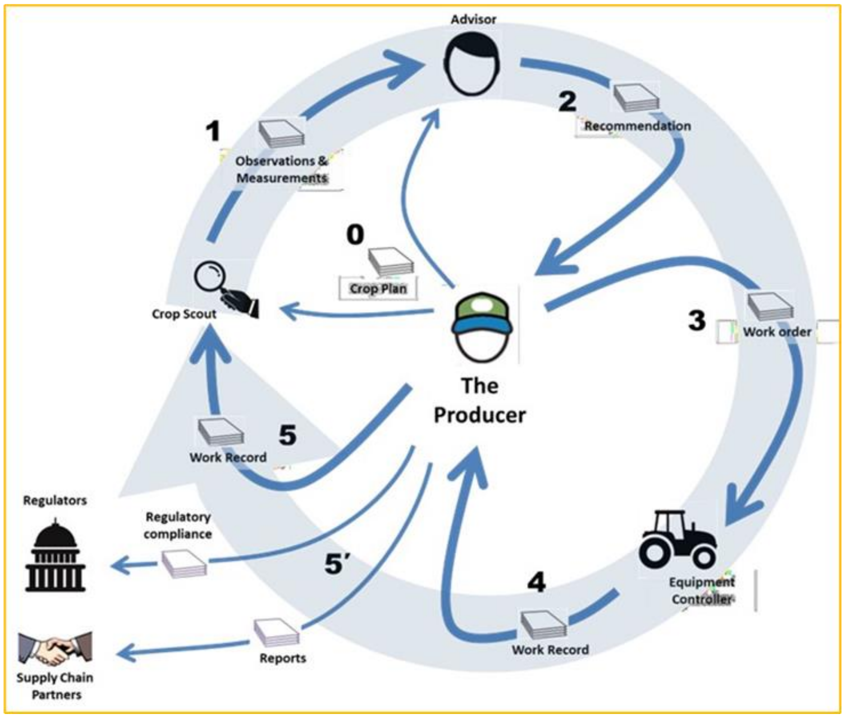


Source: *Sashieka Seneviratne, Director Sustainability Ericsson North America.*

The Importance of Digital Tools for Farmers

It is crucial to provide farmers with the digital tools they need to meet growth and sustainability goals while navigating labor shortages.

Farmers must be at the center of all broadband connectivity efforts for Precision Agriculture. They are the direct beneficiaries of these technologies and have the most at stake. Precision Agriculture relies on real-time data collection and analytics to optimize crop yields, improve water and fertilizer usage, enhance overall farm efficiency, and fulfill government reporting requirements. Reliable broadband is essential for accessing the data-driven tools that power these processes, from edge and cloud computing to remote sensing and automated machinery. All information must revolve around the farmer.



Source: *Brent Kemp AgGateway.*

Data Ownership and Stewardship

Most importantly, the data harvested by these technologies belongs to the farmer. Ensuring that farmers control their data is critical for privacy, security, and making informed decisions about their operations.

The principled sharing and use of such data is broadly termed "data stewardship," encompassing principles of ownership, privacy, terms of use, and compensation. Currently, there is no comprehensive federal regulation for agricultural data ownership, nor is there a universally accepted definition of data stewardship. Voluntary frameworks, such as the American Farm Bureau Federation's Ag Data Transparent Core Principles, offer guidelines for data use and transparency between contracting parties, but these principles are not legally binding. Organizations like the Ag Data Coalition are working to create permissioned repositories for sharing operational data based on farmer and producer decisions.

Regional standards bodies, such as AgGateway, and special interest associations like the American Feed Industry Association (AFIA), Agricultural Retailers Association (ARA), CropLife America, The Fertilizer Institute (TFI), and various commodity associations and checkoff programs are actively addressing data stewardship and interoperability.

Globally, standards set by the International Organization for Standardization (ISO) are becoming increasingly relevant for U.S. farmers engaged in global supply chains. While often hidden from farmers, these standards are frequently referenced in regulations, impacting the generation, exchange processes, and processing of Precision Agriculture data. Similar efforts in standards bodies overseeing telecommunications and internet engineering are also worth monitoring.

In short, broadband solutions must prioritize the farmer.

Vision for Innovation

With today's technology, we can confidently and proactively detect pests, identify various molds and fungi, and assess every aspect of soil health, providing critical insights for farmers. Low-cost sensors can monitor soil moisture, nutrient levels, and plant health, giving farmers granular data to make informed decisions. These devices, integrated with wireless networks, will help automate many aspects of farm operations, reducing labor costs and enhancing precision in resource deployment. Sophisticated control systems can automate irrigation, pesticide application, and machinery operations, minimizing human error and increasing efficiency.

The challenge lies not in technological innovation but in delivering reliable broadband connectivity to farms and extending high-speed wireless coverage across every acre. As seen in other industries, ingenuity will naturally follow once connectivity is established.

We can expect a surge of highly specialized mobile and web-based applications designed specifically for agricultural needs. Farmers will be able to monitor their operations remotely—tracking machinery, analyzing crop and soil data in real-time, and receiving instant updates on irrigation needs, weather patterns, or pest threats—all from a device in the palm of their hand.

These applications will enable real-time data processing, AI-driven decision-making, and seamless integration with autonomous equipment. The remarkable capabilities of AI to interpolate data allow a dairy in Pennsylvania to pinpoint the feed that enhances the unique flavor of their renowned cheese, turning data into a "secret ingredient."[20]

Applications known as Digital Twins will offer predictive models for crop growth, harvest readiness, and yield based on historical data, weather forecasts, and soil health sensors. They will also facilitate digital trials of different farming practices, such as regenerative agriculture, enabling farmers to weigh costs and benefits. Additionally, we will see augmented reality (AR) tools for farm management, where farmers can use AR glasses or mobile devices to visualize nutrition absorption or water stress. Cloud-based platforms will simplify access to global markets and improve supply chain transparency.

Looking ahead, the agriculture sector will continue to benefit from more powerful and autonomous AI systems. As computing power and data availability grow, models that can self-learn and adapt across a wide range of conditions will become indispensable in agriculture. Artificial General Intelligence (AGI), edge AI, and self-supervised learning will redefine farm management, increasing efficiency and resilience in a changing climate. (See AI overview in Appendices)

[20] Daniel Foy

Connectivity will open the door for creative business models in agriculture, particularly around service-based farming for data-driven decision-making. For instance, farms may subscribe to platforms that offer real-time analytics for risk management and predictive crop modeling. These models could transform traditional farming from a capital-intensive industry to a service-oriented, subscription-based model, where farmers lease advanced technology instead of purchasing it outright. Cloud-based platforms could provide predictive insights that help farmers decide what to plant, when to harvest, and how to optimize their supply chains—creating new revenue streams and opportunities.

Precision Agriculture applications integrated into these business models may include:

- **Low-Cost, Sophisticated Sensors, Devices, and Controls:** The cost of advanced technology, such as sensors and controls, is expected to decrease due to economies of scale and widespread adoption. These sensors will also become more sustainable as next-generation wireless networks become commercially available.

- **Autonomy:** Autonomy in agriculture will transition from concept to reality. Autonomous tractors, drones, and robots will function seamlessly across fields, guided by real-time data from sensors and cloud-based platforms. These machines will perform tasks such as planting, fertilizing, and harvesting with incredible precision, reducing labor needs and improving productivity. For instance, self-driving tractors could operate around the clock, making farming operations more efficient and scalable.

- **Full Automation:** Full automation goes beyond autonomy by enabling entire farming processes to run without human input. This involves a combination of robotics, machine learning, and real-time data analysis to create systems that manage themselves. With fully automated processes, farms could monitor crop growth, apply fertilizers, detect and treat diseases, and harvest crops—all without human intervention. This level of automation would lead to fewer resource inputs and waste while increasing overall productivity. Growers would have the freedom to operate their farms remotely, which is especially beneficial for those with plantings spread over wide distances.

- **Miniaturization:** Smaller, more powerful sensors and machines will be able to collect data and perform tasks in previously inaccessible environments. For example, tiny drones or under-canopy robots could monitor crops at the leaf level, identifying pests or diseases early on. This capability will enable precision interventions, reducing the need for large-scale pesticide applications and improving sustainability.

- **Robotics:** Robots will automate labor-intensive tasks such as planting, weeding, and harvesting. Connectivity allows for real-time control and monitoring of these machines, ensuring they operate precisely and adapt to changing conditions.

- **Drone Imagery:** Drones equipped with high-resolution cameras and sensors can capture detailed aerial imagery of crops. These images can be processed through cloud-based platforms to analyze crop health, soil conditions, and even detect pests or diseases before they become widespread. Farmers can use this data to make informed decisions about where to apply treatments, water, or nutrients, thus optimizing resource use and boosting crop yields.

- **Aerial Applicators:** Aerial applicators, such as drones, can apply fertilizers, pesticides, or seeds with precision, using real-time data to target specific areas in need. With more reliable data and control, these systems will reduce waste, minimize environmental impact, and ensure that only the necessary amounts of chemicals are used. Connectivity allows for immediate adjustments based on weather or field conditions, making aerial applications more efficient, effective, and safer.

- **Ground Rovers:** Ground rovers will become increasingly important in automating tasks such as planting, fertilizing, and harvesting. These autonomous vehicles will operate across fields, using data collected from sensors and the cloud to navigate and make real-time decisions. They can perform repetitive tasks with precision and consistency, reducing the need for manual labor and increasing overall farm efficiency.

- **Under-Canopy Crop Scouts:** Under-canopy crop scouts, typically small robots or drones, can navigate beneath crops to monitor growth, detect pests, and gather data at a micro level. This technology allows farmers to gain insights into plant health that would be difficult or impossible to see from above. By collecting data from beneath the canopy, these scouts can help farmers identify issues earlier, enabling more targeted treatments and improving crop health.

  Under-canopy scouts could hypothetically face performance challenges depending on the network used. For instance, CBRS signal quality may be degraded by dense vegetation, tree trunks, and moisture, which can attenuate signals. These barriers might result in unreliable connectivity for under-canopy sensors or devices unless the network infrastructure is carefully designed to mitigate such issues.

  While there are numerous workarounds, the challenge remains that these solutions are often bespoke. This potential scenario illustrates the truism that “if you’ve seen one farm, you’ve seen one farm.”

  The key question is how to design policy and funding mechanisms that embrace and support this individuality. As connectivity advances in agriculture, farmers stand to gain numerous advantages that enhance their business models, driving efficiency, sustainability, and innovation.

- **Data-Driven Decision-Making:** As connectivity improves, farmers will increasingly rely on data-driven decision-making to enhance productivity and sustainability. By leveraging advanced analytics, farmers can gain insights into crop performance, soil health, and market trends. This data can inform decisions on crop rotation, resource allocation, and risk management, ultimately leading to more efficient operations and higher yields.

- **Subscription-Based Services:** The shift toward subscription-based services will allow farmers to access cutting-edge technology without the upfront costs associated with purchasing equipment. For example, farmers could subscribe to platforms that provide access to advanced analytics, precision farming tools, and even expert consultations. This model not only lowers financial barriers but also encourages continuous innovation, as service providers will be motivated to keep their offerings up to date.

- **Collaborative Platforms:** Connectivity will also foster collaborative platforms where farmers can share data and insights with one another. By pooling resources and knowledge, farmers can make more informed decisions and collectively address challenges such as pest management and market fluctuations. These platforms could facilitate peer-to-peer learning and support networks, enhancing community resilience in the face of agricultural challenges.

- **Enhanced Supply Chain Management:** With improved connectivity, farmers can optimize their supply chains more effectively. Real-time data on inventory levels, market demand, and transportation logistics will enable farmers to make timely decisions about when to harvest, how much to produce, and where to sell their products. This agility can lead to reduced waste, increased profitability, and better alignment with consumer preferences.

In summary, the integration of connectivity in agriculture will pave the way for innovative business models that prioritize data-driven decision-making, subscription-based services, and collaborative platforms. As these models take shape, they will empower farmers to navigate the complexities of modern agriculture, ultimately leading to a more sustainable and productive food system.

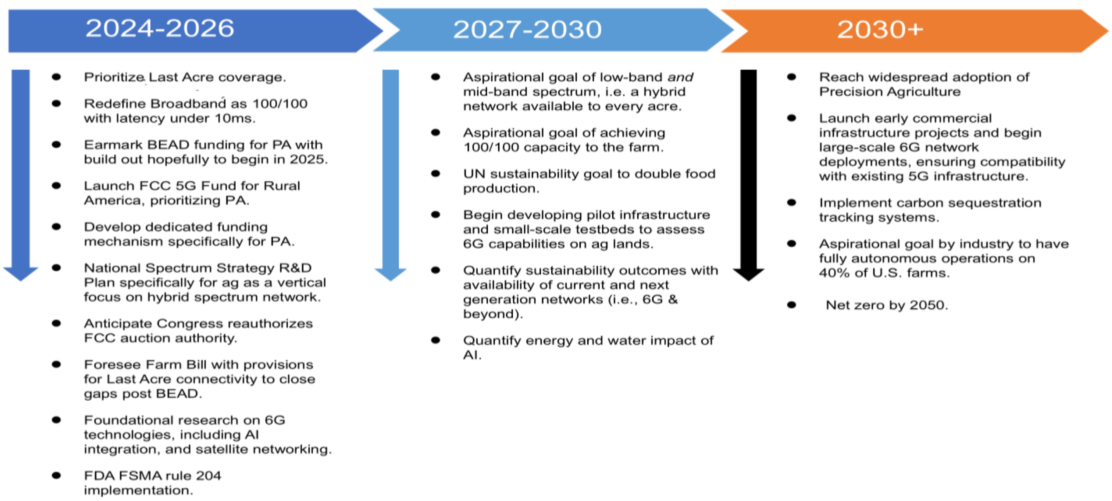
This Working Group recommends that the USDA and the FCC, in conjunction with the NTIA, design a policy and funding framework that includes the necessary engineering and network design expertise to enable business models.

Timeline: Goals and Milestones

Broadband connectivity and cloud innovation are poised to drive significant advancements in agriculture, enabling technologies such as real-time equipment monitoring, predictive analytics for weather and crop yield forecasting, and blockchain-based supply chain traceability. These innovations are transforming farm management and monitoring, optimizing operations to achieve increased productivity and sustainability.

The timeline for the evolution of these technologies will depend on several factors, including infrastructure development, regulatory impacts, the pace of technological adoption within the agricultural sector, and the future state of broadband, particularly regarding spectrum policy.

The chart below illustrates the anticipated timeline for integrating these tools into farming practices and when we might expect their full impact on agricultural efficiency and sustainability.



This roadmap accounts for key milestones such as the full-scale, widespread deployment of 5G in farming regions, advancements in Precision Agriculture tools and their adoption, and the evolution of regulatory frameworks that support the digital transformation of agriculture.

Conclusion

Precision Agriculture at full tilt is all about harnessing data and leveraging computational power to turn it into actionable information, addressing the challenges of feeding the planet.

We advocate for higher bandwidth that leads to transformative solutions, emphasizing the need for fiber optic connections to be extended directly to farm premises. This will provide high-capacity, reliable internet service, essential for enabling data-intensive operations, edge/cloud computing, and establishing the foundation of a connected farm.

Last Acre coverage requires comprehensive wireless connectivity—such as 5G, 6G and beyond, fixed wireless, or other IoT-enabling networks—across the entirety of the farm. This coverage is crucial for managing IoT systems that operate machinery, monitor crops and livestock, and provide real-time data for precision agriculture.

Together, these solutions address both the infrastructure needed to bring connectivity to the farm (Last Mile) and the technology required to cover and manage operations across the entire farm (Last Acre).

The byproduct of all these on-farm functions is a vast amount of data. Harnessing this resource is the key to maximizing the transformative power of Precision Agriculture.

As a vision statement for connectivity in Precision Agriculture, we recommend adopting a strategic framework based on four core pillars:

1. **Last Acre Connectivity**
    - **Prioritize High-Capacity Internet**: Ensure farm-wide internet connectivity to support real-time monitoring and data collection for Precision Agriculture.
    - **Targeted Funding**: The FCC, NTIA, and USDA should provide targeted funding to guarantee that farms have high-speed connectivity essential for Precision Agriculture.
    - **Extend Fiber Networks**: Focus on deploying fiber to farms to enable efficient data processing and support advanced farming technologies.
2. **Symmetrical Bandwidth and Latency Goals**
    - **Achieve 100 Mbps Speeds**: Establish low latency (under 10 milliseconds) for advanced applications, including IoT devices, autonomous machinery, and real-time decision-making.
3. **Technology Ecosystem**
    - **Integrated Technology Environment**: Create a comprehensive system where fiber, wireless technologies, and edge/cloud computing work together seamlessly. This redundant system should envelop the entire farm, supporting real-time data and precision operations across agricultural activities.
4. **Spectrum Access**
    - **Ensure Mid-Band and Low-Band Spectrum**: Provide access to both mid-band and low-band spectrum for efficient, wide-area farm connectivity, which is crucial for the success of Precision Agriculture.

These pillars are essential for creating a comprehensive, tech-integrated agricultural ecosystem that fully supports the advanced technologies necessary for modern, data-driven farming operations.

Source: *Venky Swaminathan, Trilogy Networks, Inc., art generated in Microsoft Designer.*

4. About Us and Processes:

We operated under the understanding that this is the final term of the Task Force, which adds urgency to our mission of achieving robust connectivity across agricultural lands. Without this connectivity, all our recommendations become moot.

After reviewing the reports from the previous two terms, we concluded that both groups successfully addressed key issues. Our task was to build on their findings, bringing greater specificity to areas such as bandwidth, latency, spectrum, and the on-premise technology ecosystem. We aimed to refine the concept of the Last Acre in a more strategic and technological sense, ensuring clarity on its conceptual and practical functions. In essence, our report can be summarized in three words: “Last Acre. Go.”

A sense of urgency and passion underpins our approach. We recognize the need for a clear, strategic path forward, complete with a timeline that includes specific milestones and goals.

One challenge we face is the limited number of real-world use cases to study, largely due to inadequate connectivity in many regions. Consequently, there has been a greater focus on large operations and major commodity crops. Smaller farms and specialty crops—

such as fruits, vegetables, nuts, and vineyards—require tailored technological approaches due to their diverse growing conditions and higher labor needs.

The use cases from the last term remain highly relevant:

1. **Autonomous Tractors**: Consideration of GPS fallibility is essential.

2. **Variable Rate Irrigation**: This pilot program has expanded to 400 acres, maintaining a 10% water savings result.

3. **Livestock Operations**: Incorporating edge computing would enhance the model.

Ultimately, this report represents our effort to define a clear path forward, grounded in urgency, innovation, and a commitment to comprehensive connectivity for agriculture.

Subgroups

We organized into four subgroups, each focused on a specific aspect of agricultural connectivity:

1. **Infrastructure** – Led by Steven Strickland and George Woodward
    - Focused on capturing the full spectrum of infrastructure necessary to maintain a viable agricultural industry.
    - Reassessed short-term bandwidth needs for premise equipment and edge computing.
    - Identified long-term digital transformation drivers.

2. **Use Cases** – Led by Brent Kemp and Ryan Krogh
    - Reviewed the three use cases from the last term, exemplifying water conservation, fully autonomous systems, and livestock management.

3. **Sustainability and Traceability** – Led by Andy Bater and Joy Sterling
    - Worked on solutions to enhance sustainability and enable full traceability across the agricultural supply chain.

4. **Viability** – Led by Dan Maycock and Steven Hill

Ensured the commercial viability and practicality of the technologies and strategies we recommend.

Timeline and Strategic Path Forward

We collaborated as a group to develop a comprehensive timeline of goals and milestones, outlining a strategic path forward. This timeline is intended not as a forecast but as a leadership guide for the FCC and USDA, highlighting our recommendations.

Presenters and Subject Matter Experts

- **Ali Khayrallah, Ericsson**: Argues that digital inequality is a financial issue rather than a technological one. He recommends leveraging mainstream mobile technology, increasing the availability of spectrum in rural areas, and maximizing commercially available spectrum to ensure compatibility and establish common standards.
- **Andrew Kennedy, New Era Partners**: Emphasizes that traceability requires connectivity down to the last acre.
- **Sashieka Seneviratne, Director of Sustainability, Ericsson North America**: Highlights the role of 5G, necessity for mid-band spectrum and outlook of sustainability with future generations of mobile network infrastructure.
- **David Love, Cherie Kagan, James Krogmeier, Troy Olsson, and Bob Brier, NSF Internet of Things for Precision Ag Center Engineering Research Center**: Stress the importance of low-band spectrum.
- **FDA Traceability Project Manager**: Focuses on food safety and traceability.
- **Daniel Foy, Co-Founder & CEO, AgriGates**: An expert on livestock data systems and broadband connectivity requirements, enabling IoT and big data to enhance animal welfare and the sustainability of livestock production systems.
- **Harry Crissy, GIA at Penn State**: Provides mapping that highlights the proximity of fiber to croplands.
- **Hongwei Zang, Iowa State University**: Operates a living lab that provides real-world data on agricultural connectivity needs.

Audience and Sphere of Influence

Our audience includes key stakeholders involved in the development, regulation, and implementation of agricultural connectivity:

- **FCC/USDA**: Federal regulatory and agricultural agencies overseeing communication policies and rural development.
- **Congress**: The legislative body responsible for creating and approving policies and funding for agricultural and technological initiatives.
- **NTIA**: The National Telecommunications and Information Administration, which advises the government on telecommunications and information policies.
- **Industry**: Private sector entities, including technology providers, agricultural companies, and broadband operators, driving innovation and implementation.
- **Farmers**: The primary beneficiaries and key implementers of agricultural technology, essential for adopting new systems and practices.
- **Rural Communities**: Regions that rely on improved connectivity for agricultural development, economic growth, and community well-being.
- **NOAA**: The National Oceanic and Atmospheric Administration, relevant for weather data, climate monitoring, and environmental factors affecting agriculture.
- **FDA**: The Food and Drug Administration, overseeing food safety, regulations, and standards, particularly relevant to traceability and sustainability.
- **State Broadband Offices**: Local government entities responsible for implementing and coordinating broadband expansion efforts within their respective states.

One of our goals is to raise awareness among these key stakeholders when Task Force reports are published.

Top 10 Working Group Recommendations

1. **Prioritize Last Acre Connectivity**: Sustainability, particularly farm-to-fork traceability, necessitates Last Acre connectivity, with food safety being of utmost importance.
2. **Deploy Fiber to the Farm Edge**: Leverage insights from Penn State's proximity maps, which indicate that 96% of all croplands are within 10 miles of existing fiber infrastructure.
3. **Redefine Bandwidth Standards**: Establish new standards of 100/100 Mbps with latency under 10 milliseconds.
4. **Allocate More Spectrum**: Increase both mid-band and low-band spectrum for agricultural use to support a comprehensive range of Precision Ag tools, from drones to soil sensors.
5. **Earmark BEAD Funding for Precision Agriculture**: Designate once-in-a-generation BEAD funding for Precision Agriculture, noting that these funds flow through the states, with much yet to be allocated.
6. **Expand 5G Networks**: Enhance access to dense, always-on, ultra-reliable 5G cellular networks through the $9 billion 5G Rural Fund, facilitating crop monitoring systems such as IoT and robotic technologies.
7. **Establish Policy and Funding Mechanisms**: Create policies and funding mechanisms to assist farmers and agricultural businesses in building private and/or public-private cellular networks.
8. **Promote Standardization**: Standardize hardware, protocols, data formats, and other technological elements (including edge and cloud computing) to ensure compatibility, scalability, and durability in sensor networks across farms.
9. **Incentivize On-Farm Data Capacity**: Enhance on-farm data capacity and processing through Edge Computing to mitigate bandwidth limitations, streamline data management, enable virtual experimentation to reduce inputs, and ensure data privacy.
10. **Analyze Unserved/Underserved Areas Post-BEAD**: Assess unserved and underserved areas based on approved deployment (not waiting for buildout) and incentivize targeted development of high-performance wireless connectivity (both terrestrial and satellite) to bridge those gaps, ultimately reaching farm and ranch premises.

5. Appendices

Working Group Members

Chair:
Joy Sterling, Partner & CEO, Iron Horse Vineyards

Vice Chairs:
Brent Kemp, President & CEO, AgGateway Corporation

Steven Strickland, Senior Market Development Executive, Insight

Members:
Andy Bater, Farmer, Fifth Estate Growers LLC

Steven Hill, President, Satellite Broadcast & Communications Association (SBCA)

Ryan Krogh, Global Combine and FEE Business Manager, John Deere

Dan Maycock, Chief Data Officer, Agerpoint

George Woodward, President & CEO, Trilogy Networks

Federal Agency Liaisons

Emily Caditz, Designated Federal Officer (DFO), FCC

Megan Danner, Attorney Advisor, FCC

Grant Lukas, Attorney Advisor, FCC

Andre Boening, USDA

Presentations

George Woodward - AI Models for Preci

Dan Foy Precision Livestock Farming.p

Brent Kemp Standards for FCC V

Ali Khayrallah Presentation 4.18.24

Sashieka Seneviratne 5G_6G a

IoT4Ag Challenges_and_Op

IoT4Ag 3GPP Technical Report.do

Hongwei Zang ARA_Vision.pdf

Hongwei Zang ARA Design & Implemen

Harry Crissy BROADBAND SERVIC

ENCOURAGING ADOPTION OF PRECISION AGRICULTURE AND AVAILABILITY OF HIGH-QUALITY JOBS ON CONNECTED FARMS

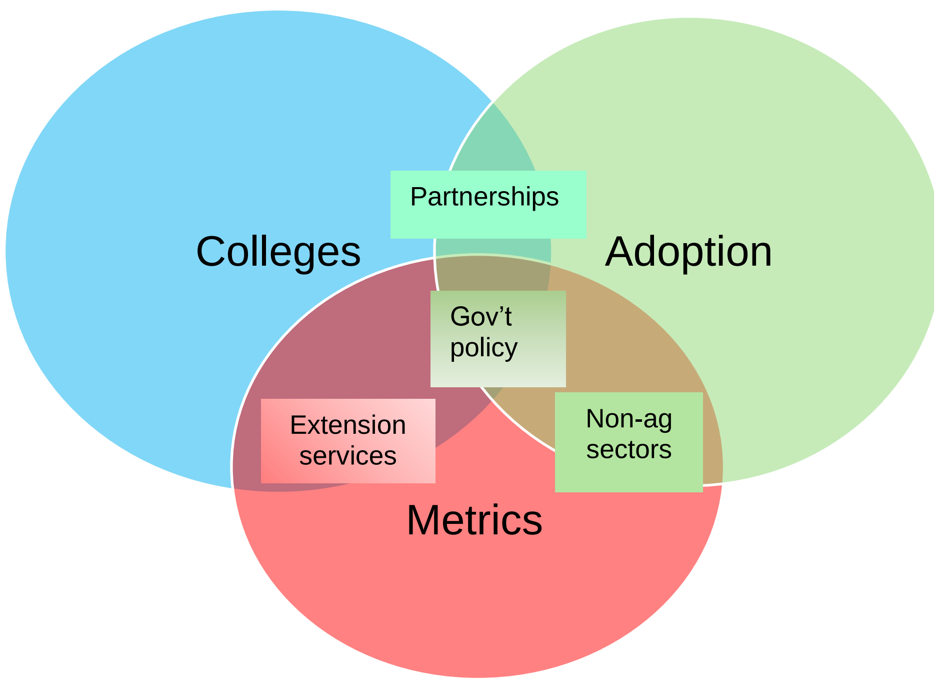
Introduction and Overview

The FCC charged the Adoption and Jobs Work Group (Work Group) to evaluate seven issues:

- Charge 1: Whether and how the adoption of precision agriculture, including automated farming, can alleviate problems farmers are facing related to labor shortages and how to further increase demand for technologically skilled workforce in agricultural areas via the adoption of precision agriculture.
- Charge 2: Ways that government, including the Commission, the Department, and state and local governments, can promote adoption of precision agriculture through policies, regulations, and outreach.
- Charge 3: Ways that government, including the Commission, the Department, and state and local governments, can promote community colleges and universities so that they can continue to grow programs in precision agriculture technology.
- Charge 4: Means for government to partner with industry and stakeholders to promote adoption of broadband Internet access services on farms and ranches and promote precision agriculture and its uses to address labor shortages and make available high-quality jobs.
- Charge 5: Obstacles farmers and ranchers face to adopting precision agriculture.
- Charge 6: Whether any work has been done in this area to date and whether there are lessons from adoption-related efforts in other contexts to apply in the precision agriculture and connected farms context.
- Charge 7: Metrics that the Commission could apply to measure and track progress towards broadband deployment and precision agriculture adoption on farms and ranches.

The Work Group developed a plan to supplement experience-based perspectives of its members with presentations from subject matter experts (SMEs) in relevant fields. The outcomes of presentations and subsequent dialogue among Work Group members and

SMEs formed the basis for the Work Group's report. Notably, the Work Group found that while it approached each of the seven issues on an individual basis, interrelations among the issues emerged as each was explored. For example, the development of post-secondary educational programming (Charge 3) suggests the need to develop partnerships (Charge 4) that benefit from government support (Charge 2). At the same time, strategies to resolve obstacles that farmers and ranchers face in adoption (Charge 5) are informed by studying progress in this industry to date (Charge 6) as well as lessons learned from other industries including healthcare and manufacturing. Finally, the evaluation of the recommendations as they may be implemented, and their collective success, relies on reasoned articulation and application of metrics that can measure success and signal where adjustments may be necessary. The Work Group accordingly envisions its charges as overlapping and intersecting with each other.



As a closing observation, the drive to increase ag tech encounters issues that are unique to each farm size, crop grown, animal raised, and the perspective of each farmer, the last of which often reflects age and familiarity with technology. Accordingly, the Work Group recommendations embrace large, broad-scale principles that, while relying on Federal guidance and leadership, will be best reflected through localized implementation involving the work of states, professional farming and trade associations, university extension services, and partnering organizations who each bring expertise to the effort.

Charge 1
Whether and how the adoption of precision agriculture, including automated farming, can alleviate problems farmers are facing related to labor shortages and how to further increase demand for technologically skilled workforce in agricultural areas via the adoption of precision agriculture.

Guest speaker: Baxter Clark, VP Agriculture, Sugar Cane Growers Cooperative of Florida (Belle Glade, FL)

Executive Summary

Ag tech will play a key role in addressing farm labor shortages. At the same time, increased proliferation of ag tech is expected to introduce significant changes.
to the farm labor market by reducing the need for low-skill labor and increasing the need for higher skilled labor to deploy, manage, maintain, diagnose, and repair complex equipment.

Background

Overview
Agricultural technology will be a key tool in mitigating human labor shortages in the agriculture industry. At the same time, it will increase demand for technology skilled workers. Technology (including, for example, ground-based machines with automatic navigation and implements, aerial drones, and broadband wireless communications) will enable farmers to reduce input costs while increasing productivity and yield. The next five years will be a critical time in which ag producers can make critical leaps to meet increasing national and global food demands while their workforces transition to new skill sets. Global food demand is expected to increase by as much as 61% between 2011 and 2050.[21]

Among the technologies currently proliferating in agriculture, automation is generally viewed as a pathway to reduced labor, as well as fuel and other input costs. By way of example, a cooperative of sugar growers in Florida spends $3 million annually to place international laborers into harvesters.[22] Those costs can be reduced significantly in a transition to automated technology. Automation can also enable more precise application of farm inputs, including seed, irrigation, and chemicals. Higher crop yields, improved animal health and monitoring, and more precise harvesting with respect to crop maturity and ripeness are among the benefits anticipated to be enabled by ag tech.

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[21] Sands, R. D., et al. "Scenarios of global food consumption: implications for agriculture," U.S. Department of Agriculture, Economic Research Service, Economic Research Report No. 323 (Sept. 2023) (https://www.ers.usda.gov/publications/pub-details/?pubid=107473).

[22] Clark, B. 2024. Personal communication.

The drive to resolve labor shortages is pressing, as the average age of the international farmworker increased from 35.8 years in 2006 to 39.5 in 2019.[23] Automation takes many forms. Automatic GPS-based guidance is now commonplace on most commercial tractors and harvesters. Modern herbicide sprayers now use AI-based image analysis to detect even small weeds for precise, automated application of chemical.[24] These findings are consistent, as well, with general impressions that ag tech lowers input costs while increasing yield.

Using automation to reduce certain human labor requirements

Increasing global demand for food, coupled with continuing labor shortages, requires policies that will encourage ag tech adoption by farms of all sizes.[25] Even as a labor shortage persists, real wages for non-supervisory farm workers increased steeply at an average annual rate of 4% between 2016-to-2022, compared to average 0.6% increases in the broader labor market from 2000 to 2014.[26] Automation can lead to labor cost savings that mitigate overall labor cost increases. Transitioning to greater incorporation of ag tech including automation will enable farmers to reduce the number

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[23] "Average Age of Hired Farm Workforce Increased from 2006 to 2019," Economic Research Service, USDA (Jun. 14, 2021) https://www.ers.usda.gov/data-products/chart-gallery/gallery/chartdetail/?chartId=101405#:~:text=The%20average%20age%20of%20all,to%2039.5%20years%20in%202019) (visited Nov. 5, 2024).

[24] Charles Gonzalez, "Automating the Risk Out of Farming," American Society of Mechanical Engineers (Jul. 30, 2020) (Reducing the Risk in Farming with Automation and Robotics - ASME) (visited May 23, 2024) (Gonzalez); "Robotic Milking," Pasture Center, W.K. Kellogg Farm, W.K. Biological Station, Michigan State University (https://farm.kbs.msu.edu/pdc/robotic-milking/#:~:text=Robotic%20milking%20technology%20(also%20referred,2000%20and%20Michigan%20in%202009) (visited May 23, 2024); *see,* "Dairy Farms in the U.S. – Employment Statistics 2004-2030," IBIS World (May 22, 2024) (https://www.ibisworld.com/industry-statistics/employment/dairy-farms-united-states/#:~:text=There%20are%20105%2C805%20people%20employed,years%20between%202018%20and%202023) (visited May 23, 2024); Hutchens, J., and Janzen, J., "Ag Market Insights: Production Trends in the U.S. Dairy Sector," FarmDoc Daily, Department of Agricultural and Consumer Economics, University of Illinois (Oct. 23, 2023) (https://farmdocdaily.illinois.edu/2023/10/production-trends-in-the-us-dairy-sector.html) (visited May 23, 2023).

[25] *See, i.e.,* "Agricultural Automation: Are Robots the Answer to Farm Labor Shortages?" CropTracker (www.croptracker.com/blog/agricultural-automation-are-robots-the-answer-to-farmer-labor-shortages.html) (visited May, 23, 2024).

[26] Bland, R., Ganesan, V., Hong, E., Kalanik, J, "Trends Driving Automation on the Farm," McKinsey & Company (May 31, 2023) (www.mckinsey.com/industries/agriculture/our-insights/trends-driving-automation-on-the-farm) (visited May 23, 2024).

of full-time employees (FTE) or FTE equivalents in the field. This will be especially useful where farms rely on difficult-to-obtain, mostly international, seasonal workers;[27] on average, 40% of ag labor is seasonal.[28] Overall, however, the total number of farm workers declined 67.88% from 1950-2020.[29] The use of robots can also reduce the likelihood of farm worker injuries. Interest in injury reduction has formed the basis for innovative partnerships to promote ag tech (*see* Charge 4, p.97) for a description of a collaborative effort among an insurance provider, a state farm bureau, and a land grant university). Whether rooted in automation or AI or other technology categories, ag tech does not perform tasks independently, but rather requires a human to oversee its implementation of those tasks. This can be expected to create a need for technology-capable workers in local farming communities. Upskilling ag workers will most effectively include training students on bundles of equipment and common core technology including computer coding and mechatronics. Additionally, higher wages paid to upskilled workers can be expected to deliver benefits to local industry and economies.[30]

Although automation can reduce some labor needs and other input costs, technology costs may be a barrier for small farmers.[31] Lack of interoperability can also be a

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[27] *See,* Rose, D. C., and Bhattacharya, M., "Adoption of Autonomous Robots in the Soft Fruit Sector: Grower Perspectives in the U.K.," Smart Agricultural Technology (Feb. 2023) (https://doi.org/10.1016/j.atech.2022.100118) (visited Jul. 30, 2023); *see, also,* Logan Kugler, "Addressing Labor Shortages with Automation," Communications of the ACM (Jun. 1, 2022) (https://cacm.acm.org/news/addressing-labor-shortages-with-automation/) (visited Jul. 30, 2022).

[28] "ERS Charts of Note," Economic Research Service, USDA (Oct. 28, 2024) (https://www.ers.usda.gov/data-products/charts-of-note/charts-of-note/?topicId=fdd8b81d-13ff-46f8-8bbc-94be42c9d9cf) (visited Nov. 25, 2024).

[29] "Farm Labor," Economic Research Service, USDA (Aug. 7, 2023) (https://www.ers.usda.gov/topics/farm-economy/farm-labor/) (visited May 23, 2024).

[30] *See, i.e.,* Emanuel, Natalia, and Harrington, Emma, "The Payoffs of Higher Pay: Elasticities of Productivity and Labor Supply with Respect to Wages," Harvard University (Jan. 12, 2020) (https://scholar.harvard.edu/files/nataliaemanuel/files/emanuel_jmp.pdf) (visited Aug. 20, 2024); *see, also,* Cooper, Daniel H., Luengo-Prado, Maria J., and Parker, Jonthan A., "The Local Aggregate Impacts of Minimum Wage Increases," Federal Reserve Bank of Boston (2017) (https://www.bostonfed.org/publications/research-department-working-paper/2017/the-local-aggregate-effects-of-minimum-wage-increases.aspx) (visited Aug. 20, 2024).

[31] *See,* "How to Cut Costs with Smart Farming Technology," AgAmerica (Aug. 23, 2023) (How To Cut Costs with Smart Farming Technology | AgAmerica) (visited May 23, 2024).

disincentive to adoption if farmers cannot integrate new equipment with existing machines and cropping systems (for additional information about obstacles to adoption, *see* Charge 5, p.100[]). In some communities, a focus on sustainability and carbon footprint reduction will be an important selling point. Moreover, if farming is viewed as a "business of logistics" (planting, feeding, harvesting, and delivery to market at "the right time,") then AI and robotics that assist farmers to harvest crops at peak maturity/ripeness are necessary tools. Automated systems that allow multiple passes through the same area for selective fruit harvesting are in development,[32] and camera-based classification systems can increase yield at the farm and reduce food waste in transit, warehouses, and production/retail facilities.

Ag tech implicates the need for greater attention to cyber security as usage increases and more data is collected and committed to cloud-based systems. As ag tech comprises more applications for crops and livestock, the potential threat to the ag industry increases. Threats to trade secrets, consumer privacy, and financial data arise at several points; vulnerable gateways may exist at sensors; IoT devices; cloud-based systems; and remote-control and autonomous equipment such as drones manufactured in foreign countries.[33] Adversarial or even unintentional interference can cause wide-reaching impacts by compromising the security and integrity of IoT devices and automated systems. For example, instructions can disable devices or attack with data injection, where real-time data is falsified to prompt harmful incorrect reactions. Threats to national food supplies that in turn can create significant national security consequences are referred to as "agroterrorism."[34]Agricultural machinery in crop and animal farming could be directed to cause harm, and sensors could be manipulated to skew planting, feeding, and harvest cycles, while irrigation systems can be compromised to under- or over-irrigate fields and orchards.[35] Attacks on pricing systems can affect land sale prices and crop insurance rates.[36] The USDA Agricultural Marketing

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[32] *See,* "Apple-Harvest Robot Roundup – Video," Good Fruit Grower (Dec. 7, 2022) (https://www.goodfruit.com/lots-of-bots-video/) (visited Sep. 11, 2024).

[33]*See*, Konstantinos, Demestichas; Peppes, Nikolaus; Alexakis, Theodoros, "Survey on Security Threats and Agricultural IoT and Smart Farming," Sensors, MDPI, at 8 (2020) (https://www.mdpi.com/1424-8220/20/22/6458) (visited Mar. 19, 2021) (Konstantinos, et al.); *see, also,* "Cybersecurity Guidance: Chinese Manufactured UAS," Cybersecurity and Infrastructure Security Agency (Jan. 17, 2024) (https://www.cisa.gov/resources-tools/resources/cybersecurity-guidance-chinese-manufactured-uas) (visited Nov. 25, 2024).

[34] *See, i.e.*, Konstantinos, et al., at 6.

[35] "Threats to Precision Agriculture," 2018 Public-Private Analytic Exchange Program, U.S. Department of Homeland Security, at 18 (2018) (DHS).

[36] DHS at 4, 17.

Service (AMS) has taken notice of these threats. In a recent release, it asked, "What roles should the USDA AMS play in helping defend critical infrastructure and ensure viable supply chains in the U.S. grain industry?"[37] In 2023, food and agriculture ranked 7th among 11 industries tracked by an ag information sharing and analysis center (ISAC), representing 5.5% of total ransomware attacks (critical manufacturing and financial services were 15.5% and 12.4%, respectively).[38] The USDA warns, "[a]n attack during peak seasons could significantly disrupt the supply of essential goods such as seeds and fertilizers, thereby affecting planting schedules and, ultimately, the supply chain."[39] By way of example, in June 2021, a ransomware attack resulted in disruptions at the world's largest meat packing firm. The company paid an $11 million ransom.[40]

The Federal Bureau of Investigation has recognized these threats, citing 18 U.S.C. § 1831 (Economic Espionage) and § 1832 (Theft of Trade Secrets) as laws that could be violated through either the targeting or theft of trade secrets.[41] In 2019, the U.S. District Court for Eastern Missouri indicted a foreign national who worked for a U.S. company that estimates soil properties based on satellite imaging.[42] Other instances of agricultural espionage include theft of modified seed samples and corn growing strategies.[43]

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[37] "GIAC Cyber Security Discussion Paper," USDA Agricultural Marketing Service, at 1 (2024) (https://www.ams.usda.gov/about-ams/giac-may-2024/meeting/cybersecurity) (visited Sep. 24, 2024) (USDA AMS).

[38] "Farm-to-Table Ransomware Realities: Exploring the 2024 Ransomware Landscape and Insights for 2024," Food-Ag ISAC (Apr. 2024) (https://www.foodandag-isac.org/_files/ugd/b9866c_a7e67fbd39ce40a6a7ae578b1885e663.pdf) (visited Sep. 25, 2024).

[39] USDA AMS at 3.

[40] "JBS Paid $11 Million to Resolve Ransomware Attack," Jacob Bunge, Wall Street Journal (Jun. 9, 2021) (https://www.wsj.com/articles/jbs-paid-11-million-to-resolve-ransomware-attack-11623280781) (visited Jun. 14, 2021).

[41] "Agricultural Economic Espionage: A Growing Threat," Federal Bureau of Investigation, U.S. Department of Justice (https://ucr.fbi.gov/investigate/counterintelligence/agricultural-economic-espionage-brochure) (visited Mar. 19, 2021).

[42] See, Edwards, Julia, "In Iowa Corn Fields, Chinese National's Seed Theft Exposes Vulnerability," Commodities News (Apr. 11, 2016) (https://www.reuters.com/article/us-usa-china-seeds/in-iowa-corn-fields-chinese-nationals-seed-theft-exposes-vulnerability-idUSKCN0X80D6/) (visited Mar. 22, 2021).

[43] *See,* "Chinese National Who Worked at Monsanto Indicted on Economic Espionage Charges," U.S. Department of Justice, U.S Attorney's Office, Eastern District of Missouri

Potential improper access by foreign actors has been noted in both general telecommunications and ag focused applications.[44] The Commission is currently implementing the Secure and Trusted Communications Networks Act of 2019, which is intended to prevent the use of equipment or services that pose a national security risk in U.S. networks.[45] This law requires communications network operators to remove certain equipment and services and replace them with components that are approved by the Commission.[46] On the consumer side, the Commission recently adopted voluntary industry standards for IoT cybersecurity labeling.[47] This framework creates an IoT labeling program that relies on public, private, and academic sector partners. On Capitol Hill, Brad Finstad (MN-01) and Elissa Slotkin (MI-07) introduced the Farm and Food Cybersecurity Act (H.R. 7062) to fortify cybersecurity protections for the nation's food system. The bill would require the Secretary of Agriculture to conduct a biannual study of threats and vulnerabilities, and to coordinate with the Homeland Security, Health and Human Services, and the Director of National Intelligence to conduct simulation exercises of cyber-related emergencies and disruptions.[48]

Recommendations

Ag tech enables increased productivity alongside lower input costs, including materials/supplies and labor. Reducing labor inputs can be expected to reduce the need for unskilled workers while increasing the need for a cohort of more highly skilled workers. It can be anticipated that the emerging cohort of more highly skilled workers will be more useful to the industry if they work and/or reside proximate to the higher tech equipment that is being used on the farm. University research and extension efforts can lead in the development and demonstration of new technology and provide key partners in training and education of new high-skill farm workers.

(Nov. 21, 2019) (https://www.justice.gov/usao-edmo/pr/chinese-national-who-worked-monsanto-indicted-economic-espionage-charges) (visited Mar. 22, 2021). *See, also,* Clayton, Chris, "China Caught Stealing Ag Tech," Ohio's Country Journal/Ohio Ag Net (Nov. 25, 2019) (https://ocj.com/2019/11/china-caught-stealing-ag-tech/) (visited Mar. 22, 2021).

[44] *See,* Konstantinos, et al., at 5.

[45] *See,* Secure and Trusted Communications Networks Act of 2019, Pub. L. 116-124, 134 Stat. 158 (2020).

[46] *See, generally, Application of Section 4 of the Secure and Trusted Communications Networks Act of 2019 to the Commission's Rulemaking on Protecting Against National Security Threats to the Communications Supply Chain,* FCC Docket No. 18-89.

[47] *See, Cybersecurity Labeling for Internet of Things: Report and Order and Further Notice of Proposed Rulemaking,* FCC Docket No. 23-239, FCC 24-26 (2024).

[48] "Farm and Food Cybersecurity Act of 2024, H.R. 7062, 118th Cong. 2023-2024 (2024) (referred to the House Committee on Agriculture, Jan. 22, 2024).

- Ag tech should be recognized as a critical tool in addressing human labor shortages while increasing demand for skilled workers.

- Federal policy should support industrial and educational efforts to upskill farm workers with training in both specific equipment and common core technology.

- The FCC and USDA should identify the risk of cyber-security threats in agriculture and coordinate with DHS and other agencies of jurisdiction to identify vulnerabilities and potential remedies, and they should coordinate to educate farmers and other stakeholders about cyber threats, including but not limited to FCC IoT labeling.

Charge 2
Ways that government, including the Commission, the Department, and state and local governments, can promote adoption of precision agriculture through policies, regulations, and outreach.

Charge 3
Ways that government, including the Commission, the Department, and state and local governments, can promote community colleges and universities so that they can continue to grow programs in precision agriculture technology.

Presenters: Marisa Alcrota, Land Based Learning, and Carrie Peterson, Yuba Community College District.

Executive Summary

Legislative and regulatory measures can address farm bank and credit systems to structure financing silos for grants and loans that enable small farmers to obtain broadband-enabled equipment. At the same time, colleges and universities are positioned to develop precision-agriculture technology as well as industry-oriented curriculum that evolves in concert with technology development. Government support can help these institutions not only to conduct research that develops technology, but also to play critical roles in supporting internship and apprenticeship programming. These initiatives will benefit substantially from financial bridge support to cover costs that are beyond institutional and private sector funding.

Background

Overview
Many programs to promote and support precision ag adoption already exist. The Government Accountability Office (GAO) reports on USDA and National Science Foundation (NSF) programs, among others, that collectively or separately fund precision ag research and development (R&D), education and training. GAO identified

43 separate programs overseen by 11 different Federal agencies.[49] These include, by way of example, USDA Farm Operating Loan Program and Farm Ownership Loan Program, which provide loans for numerous purposes including, but not limited to, technology and capital improvements.[50]

In addition to programs aimed at assisting farmer access to new technology, apprenticeship-type training remains a critical element of transmitting farming experience and expertise. These efforts require government and industry engagement to identify resources, potentially administered through Department of Labor (DOL) apprenticeship programming and USDA training. Currently, the DOL administers the National Farmworker Jobs Program (NFJP), a locally administered program for migrant and seasonal farm workers.[51] In 2023, the program awarded more than $90 million in grants. Program descriptions are broad (". . . occupational skills and job training, including on-the-job training and skills upgrading opportunities . . .")[52] and appear to have margins broad enough to include technical skills training. Although the program is aimed to assist migrant and seasonal workers, the program presents a framework that could be adapted to support skills training and compensation programs for college students (whether community or four-year college) who seek apprenticeship opportunities on farms. In a similar vein, the federal Registered Apprenticeship Program, which finds its roots in the 1937 National Apprenticeship Act,[53] should be explored to determine how its provisions can be applied with USDA guidance to promote precision ag. Currently, the Agricultural Technician job title, which includes the technologies of GIS, GPS, yield mapping, VRT (variable-rate technology) and other functions, is not approved for use in a Registered Apprenticeship Program.[54]

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[49] "Precision Agriculture: Benefits and Challenges for Technology Adoption and Use," U.S. Government Accountability Office, at 19 (Jan. 2024) (GAO).

[50] GAO at 20.

[51] *See,* "National Farmworkers Jobs Program," Employment and Training Administration, U.S. Department of Labor (https://www.dol.gov/agencies/eta/agriculture) (visited Aug. 20, 2024).

[52] "National Farmworkers Jobs Program," U.S. Department of Labor (https://www.dol.gov/sites/dolgov/files/ETA/Farmworker/pdfs/NFJP-Fact-Sheet-Final-6-23-23-Revised-version.pdf) (visited Aug. 20, 2024).

[53] Also known as the Fitzgerald Act and codified at 29 CFR § 29, 29 CFR § 30.

[54] "Precision Agriculture Technicians," Apprenticeship USA, U.S. Department of Labor (https://www.apprenticeship.gov/apprenticeship-occupations/listings?occupationCode=19-4012.01) (visited Aug. 20, 2024).

University programs
University research and extension efforts that play an integral role in providing resources to study farm outcomes can be leveraged to promote ag tech adoption as well as other intervening factors that affect productivity, pricing, and performance. While farmers, with or without ag tech aids, are capable of studying market trends and individual yield data, university research and extension faculty can access numerous data sets and tremendous amounts of data, analyze them in extremely detailed ways, and deploy resources to study outcomes on a scope that is unattainable to the individual farmer. Extension services can moreover convene farmers and other industry participants to obtain both quantitative and qualitative information and use those data to model conditions and develop technology and strategic responses to them. Post-secondary education can also include curriculum development and efforts to encourage and promote employment in the farm industry.

Schools with agricultural teaching, research, and extension programs will play an important role in identifying technological solutions and how related changes interface with and inspire changes within the workforce. Research and extension faculty commonly study mechanization and applied research that affect products, production systems, and management. Extension services can also contribute to addressing non-ag issues that affect the ag industry, including health care and other social issues. These, too, warrant consideration as agricultural community demographics may change with increasing automation.[55]

Land grant universities exist in every state, and cooperative extension agents and offices are in nearly every county in many states.[56] USDA, through its National Institute of Food and Agriculture (NIFA), partners with the state universities by funding projects in agricultural research, education, and extension. Working with USDA, university extension services help connect farmers and farm workers with developments in farming and agricultural technology.[57] The role of broadband as a critical link is recognized at the state land grant university level. Examples include the creation of an engineering research center at University of California, Merced, that focuses on ag

[55] *See, i.e.,* Langemeier, M., and Boehlje, M., "Precision Agriculture and Technology," Center for Commercial Agriculture, Purdue University (Apr. 15, 2021) (https://ag.purdue.edu/commercialag/home/resource/2021/04/precision-agriculture-and-technology/) (visited May 23, 2024).

[56] "Land-Grant Colleges and Universities," National Institute of Food and Agriculture, USDA (https://www.nifa.usda.gov/about-nifa/how-we-work/partnerships/land-grant-colleges-universities) (visited Aug. 20, 2024).

[57] For a general overview of how land grant universities can help rural development, *see,* Lyons, T. S., Miller, S. R., Mann, J.T., "A New Role for Land Grant Universities in the Rural Innovation Ecosystem," MCRSA Presidential Symposium (2017).

tech;[58] Mississippi State's Agricultural Autonomy Institute that focuses on integrating various ag tech including broadband to support autonomous systems for agriculture;[59] Iowa State's "ARA project," an NSF-funded project testing wireless broadband technology's role in enhancing new precision agriculture applications on the farm;[60] and Purdue University's use of broadband and UAV's (drones) to collect sensor data.[61] Moreover, the University of Nebraska recently received a $160M USDA investment to support ag tech research.[62]

Programs can traverse the range of education and farm experience, building opportunities for internships and apprenticeships that blaze a path for future farm and farm-management employment. Defined certificate and degree programs will be crucial to train workers on equipment that needs management, oversight, maintenance, repair and calibration (unlike equipment in factories, precision ag equipment must endure highly variable and often harsh conditions). Workforce development is critical as new technology not only improves existing equipment but creates new lines of equipment on which farmers will rely, including autonomous vehicles; UAVs; robots; sensor-based systems; smart irrigation, etc. These technologies require not only developers who understand the industry for which they are creating solutions, but also a corps of technicians who can deploy, maintain, diagnose, and repair. While these changes are desired and occurring, farmers also face competing forces. Domestic labor rates are high, while competing foreign rates are lower, driving lower overseas product costs and competition for U.S. producers.

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[58] Lorena Anderson, "New Engineering Research Center to Focus on Agricultural Technology," University of California (Aug. 5, 2020) (https://www.universityofcalifornia.edu/news/new-engineering-research-center-focus-agriculture-technology) (visited Aug. 20, 2024).

[59] *See, also,* "Agricultural Autonomy Institute," Mississippi State University. (https://www.aai.msstate.edu/) (visited Oct. 9, 2024).

[60] "ARA Overview," Iowa State University (https://arawireless.org/about-ara/) (visited Aug. 20, 2024).

[61] *See,* "The Big Data Harvest," Envision, Purdue University (Fall 2017) (https://ag.purdue.edu/envision/f117-data) (visited Aug. 20, 2024).

[62] "What Happens Next in Agriculture Will Happen First in Nebraska," University of Nebraska (May 8, 2024) (https://news.unl.edu/article/what-happens-next-in-agriculture-will-happen-first-in-nebraska) (visited Aug. 20, 2024).

Internship and apprenticeship programs

The Western Growers Association (WGA)[63] leveraged USDA and California Department of Food and Agriculture funding to create a multi-prong program that includes industry-guided ag tech college curriculum development and $3,000 reimbursements for specialty crop farmers who hire college students; this has been evaluated as about 40% of the cost of an intern. The program includes regional meetings to discuss technology development, skills gaps, and partnerships with post-secondary education institutions.

The WGA program is based on modules that are accessible to the online education platforms of California colleges. These address numerous ag tech issues including logic controllers, commodities, GPS, IoT, food safety, UAVs, etc. WGA reports that 1,200 students have engaged this curriculum in more than 20 post-secondary institutions and high schools. WGA also launched “LinkedAg,” an app that connects industry partners to college students and faculty to internship opportunities.

The California Farm Academy Apprenticeship (CFAA) program creates pathways toward quality jobs in farming that pay good wages. CFAA focuses on developing farm management skills, specifically a blend of technical knowledge, soft skills, and problem-solving capabilities. Like any other industry, qualified candidates will most often emerge from existing labor pools in that field, also known as “growing our own.” The CFAA program is a structured approach to this problem.

1. The state Division of Apprenticeship Standards issues a journey worker credential in farm and ranch management.

2. The apprentice completes 3,000 hours of supervised on-the-job training over a period of 18-24 months. The work encompasses eight core study areas, and wages increase every six months.

3. Participants must also complete Related Supplemental Instruction. These courses are offered virtually and in-person at no cost to the apprentice, but all 250 hours must be completed as part of the program.

The program has reached 33 farms across 18 counties, covering more than 55,500 acres. The program covers numerous roles including technology and equipment (operators and mechanics) as well as “traditional” roles relating to animal care, food safety, orchard maintenance, irrigation, and other aspects of farming. Importantly, the program cultivates soft skills such as leadership and communication, regulatory awareness, and digital literacy. These and others developed in the program are key steps toward building self-management and relationship building skills that are critical for farm management.

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[63] Kara Timmins, “Western Growers Next-Gen Ag Students are Ready for Internship Opportunities” (Apr. 16, 2024) (www.wga.com/news/western-growers-next-gen-ag-students-are-ready-for-internship-opportunities) (visited Aug. 20, 2024).

Overall, training will become more complex as the technology and systems become more complex. These contemplate everything from biodegradable sensors to drones to autonomous ground vehicles.[64] Purdue University labs host SMART: Scalable Manufacturing of Aware and Responsive Thin Films, which has developed field deployable printed nitrate sensors.[65] Purdue also offers a suite of extension programs alongside undergraduate and graduate courses and certificates in ag tech and data-science disciplines.[66]

In the post-secondary educational settings, however, hardware demo classes can be difficult from a timing perspective (*i.e.,* whether planting and/or harvesting conflicts with classes or breaks). Weather and travel to farm sites can also be factors, suggesting that small equipment that can be located closer to school as an alternative to demonstrate representative examples for exhibitions. While remote learning is a valuable tool, classroom instruction (whether virtual or in-person) must be supplemented by "field lab" opportunities where students can "kick the tires."

Additionally, efforts to reach high schools students will be critical: Future Farmers of America features ag tech focused programming, and this partnership with high schools can be promoted. These high-school programs strengthen youth programs found in land grant university extension systems that are related to ag-focused applications including drones and robotics programs coordinated with 4-H.[67]

In short, the tools exist but will require inspiring leadership and support from the Federal sector to assist with more robust development and higher participation rates.

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[64] GAO at 17, 18.

[65] *See,* Scalable Manufacturing of Aware and Responsive Thin Films, Purdue University (https://engineering.purdue.edu/SMART/Research) (visited Aug. 20, 2024).

[66] *See, i.e.,* Agricultural Economics Department's Extension Programs and Resources (www.purdue.ag/department/agecon/extension/extension-resources.html) (visited Aug. 20, 2024).

[67] *See,* "Purdue Extension's UAV Program Prepares Participants to Fly Drones for Work or Hobby," Purdue University Extension (Feb. 13, 2024) (https://extension.purdue.edu/news/2024/02/purdue-extensions-uav-program-prepares-participants-to-fly-drones-for-work-or-hobby.html) (visited Nov. 5, 2024) *and* "Robotics Youth Development Program," Mississippi State University Extension (http://4hrobotics.msucares.com/) (visited Nov. 25, 2024).

Recommendations

- USDA should expand the ability of farmers to utilize USDA loans and other programs for ag tech deployment.
- USDA should create tiered incentive and other benefit programs that contemplate the size of farm, job development, productivity savings/gains, and other criteria for loans, matching funds, and other benefits.
- USDA should support research into ROI strategies for common and specialty ag tech applications and enable resources to be administered by university education and extension programs to develop ag tech curriculum.
- USDA should work with partners to assist with the development of paid ag tech internships and apprenticeship programs, including academic credits in both 2-year and 4-year programs.
- The FCC and USDA should convene stakeholder conferences between farmers, extension services, and state employment offices to identify gaps and develop solutions.

Charge 4
Means for government to partner with industry and stakeholders to promote adoption of broadband Internet access services on farms and ranches and promote precision agriculture and its uses to address labor shortages and make available high-quality jobs.

Guest Speaker: Jeff Johnston, CoBank

Executive Summary
Partnerships among industry and stakeholders can promote adoption of broadband Internet access services on farms and ranches and promote precision agriculture. These efforts can include strategies to expand broadband deployment beyond current Federal initiatives (BEAD, USF) as well as unique partnerships between ag and non-ag sectors.

Background

CBRS deployments
While fiber has been recognized by Federal programs as the standard for broadband deployment,[68] ag tech necessarily relies on a blend of wired and mobile technologies.

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[68] *See, i.e.,* See NTIA, “Policy Notice: BEAD Selecting the Most Robust, Affordable, Scalable Technology”, at 6-8 (June 26, 2024) available at https://broadbandusa.ntia.gov/sites/default/files/2024-

Indeed, even mobile and fixed wireless services depend on fiber, but the practicality of extending fiber to farm acreage along with the need to support mobile equipment in the field necessitates a wireless broadband service component at the farms.

A wireless connection with CBRS spectrum is an alternative that can be explored. CBRS spectrum is available for licensed and licensed-by-rule use, which enables operators to deploy the spectrum without making capital investments to acquire it. Since the spectrum band is being utilized by the national wireless operators (and has been included in 3GPP standards) there is a broad ecosystem of network equipment and chipsets available. As deployments will be implemented in unserved rural areas, the networks can leverage the licensed-by-rule Genal Authorized Access portion of the CBRS band as the risk of experiencing interference in the band is low. Moreover, CBRS networks are considered "carrier grade," meaning they provide more reliable and faster data speeds than Wi-Fi-based networks, where equipment and spectrum has not been vetted by the 3GPP standards wireless body.

In a typical deployment, a farm could use existing "tower infrastructure" (*i.e.,* a grain silo) where a CBRS radio would be installed. This radio would serve two primary precision agriculture functions – act as a backhaul connection to a data center and provide connectivity for higher bandwidth applications on the farm (*e.g.,* a video camera). A long range (LoRa) transmitter that would be used for low bandwidth applications (*e.g.,* soil moisture sensors) would be connected to the CBRS radio via an ethernet connection.

For local communities, supporting this type of network deployment could offer derivative benefits. First, the network could be used to provide fixed wireless of similar capacity to nearby unserved locations. Depending on the size of the area and its density, additional radios may be needed, much the same as 5G deployment relies on antenna densification. Utilizing existing "street furniture" (*i.e.,* light poles, utility poles) could reduce the cost of deployment in some areas.

Another benefit would be the opportunity to offer wholesale roaming services to national wireless operators who do not have coverage in the area. Most new smartphones support the CBRS spectrum band, so they would be able to roam onto these networks.

The upfront cost to a 50-member farm cooperative can reasonably be estimated to be within the range of $55,000 per farm (assuming a <8,000-acre farm) with annual recurring costs of $6,000 per year.[69] The upfront costs assume a new tower structure for the radio equipment. If there is an existing structure on the farm that can be used,

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06/BEAD_Selecting_Technology_Policy_Notice_0.pdf. ("Selecting Technology Guidance"). In this Notice, NTIA set forth a hierarchy of technologies, which Eligible Entities are to use in awarding support – end-to-end fiber, then other reliable broadband technologies, and then alternative technologies.

[69] Presentation of Jeff Johnston, CoBank (Jul. 26, 2024).

the upfront cost per farm could be reduced by $20,000. Note this does not include application costs (*i.e.,* sensors, cameras).[70]

The business model for a private network is flexible. For example, a farmer co-operative could take the lead for its members and provide their portion of the capital and own the networks. They would work with the engineering design and construction companies and charge their members a fee to use the network. They would also work with local officials regarding their contribution to the project. The other option is to outsource the whole project to a third party. The third party would own and operate the network, and the local government could provide financial and/or in-kind support for the network. Another option would be for a farmer/rancher to build their own network. They could work directly with the local government to identify where the network could be used for other use cases and to secure its support.[71]

CBRS-based systems can be deployed where networks supported by Federal funding programs do not exist but should not otherwise duplicate or overbuild Federally supported networks, nor should such deployments be considered to substitute for robust broadband connections that are envisioned by Federal support mechanisms. CBRS networks would necessarily be bound by rules governing licensed and licensed-by-rule spectrum and limitations on potential interference would warrant consideration in areas where licensed services may be offered.

Ag and non-ag partnerships

An example of inter-industry partnership is the AgTech Innovation Hub at The Ohio State University (OSU). A combined effort of Nationwide Mutual Insurance Company, Ohio Farm Bureau, and OSU, the program supports applied research and interdisciplinary efforts.[72] The involvement of Nationwide Insurance, which among its services provides agribusiness insurance, reflects in part the company's interest in

[70] Presentation of Jeff Johnston, CoBank (Jul. 26, 2024).

[71] Examples of how cities have deployed wireless networks – sometimes on their own and sometimes with the help of communications companies - include: St. Vrain Valley School District in Longmont, CO deployed a private LTE network with NextLight, a municipal fiber network provider; City of Syracuse, NY and Community Broadband Networks launched Surge Link in 2023 – a CBRS pilot network covering 2,500 underserved households; Las Vegas is building the county's largest private 5G network that will support cellular, Wi-Fi, IoT, etc. Peachtree Corners, GA is deploying a 5G network for IoT applications (smart cameras, autonomous shuttle, etc.) and cellular service. Presentation of Jeff Johnston.

[72] "Nationwide, Ohio State University 'Green' Light AgTech Innovation Hub," Nationwide Insurance (Sep. 20, 2022) (https://news.nationwide.com/092022-nationwide-ohio-state-university-agtech-innovation-hub/) (visited Aug. 20, 2024).

reducing farm worker injury rates.[73] Universities, generally, can play a key role in forming partnerships aimed at (1) developing technology and (2) helping experienced farmers become comfortable with ag tech(Purdue University College of Agriculture reports helping nearly two-dozen startups).[74]

Private industry, as well, offers examples of partnerships. Grand Farm is a research and educational effort of growers, technologists, educators, developers and policy makers. The organization studies ag tech implementation issues through interviews, listening sessions, and tours, and publishes findings and discussion guides aimed at spurring increased development and deployment.[75] The group also hosts Field Days and in October 2024 hosted the Space Ag conference in Grand Forks, North Dakota. Private organizations have developed farm internship programs. For example, the National Center for Appropriate Technology offers a guide for farmers and students/workers.[76]

Consultations between tech developers and end-users will be important to ensure that technology is designed in a way that does not simply meet performance specifications but also ease of use needs for farmers.[77] For both older and younger farmers, a podcast platform for ag tech can be a valuable tool to introduce issues to interested farmers.

[73] *See,* "AgTech Innovation Hub: 2024-2025 Request for Proposals," College of Food, Agricultural, and Environmental Sciences, The Ohio State University, at 2 (Dec. 2023).

[74] "Moving Ideas from Lab to Marketplace," Purdue University College of Agriculture (https://ag.purdue.edu/plantsciences/entrepreneurship.html) (visited Sep. 11, 2024).

[75] *See,* Ruchi Joshi Bhardwaj, Andrew Jason, and William Aderhold, "Grower Pain Point Report 2023," Grand Farm (2023) (Grand Farm).

[76] "Farm Apprenticeship and Internship Resource Guide," National Center for Appropriate Technology (Apr. 2023) (https://attra.ncat.org/publication/farm-apprenticeship-and-internship-resource-guide/) (visited Sep. 11, 2024).

[77] Joe Waddell, "The Nuts and Bolts of Bolstering Ag Tech Reaction," Horizon Farm Credit (Mar. 20, 2024).

Recommendations

- The FCC and USDA should assist farmers and coops with the exploration of unlicensed spectrum where licensed or federally supported services are not available.

- Federal programming should support partnerships and relationships among farmers and non-ag sectors who share common goals.

- Federal policies should support university research and extension efforts in working with farmers to develop economic evidence to enable advocacy for ag tech

- Federal policies should support development of digital literacy, skills, and adoption.

Charge 5
Obstacles Farmers and Ranchers Face to Adopting Precision Agriculture

Presenters:
David Tindal, Tindal Farms, LLC, and Allan Gavin, Oak III Farms, Summerton, NC

Executive Summary

Technology costs and access to broadband remain barriers to wider spread ag tech deployment. Small farmers in particular face significant challenges extracting reasonable returns on investment; these challenges are heightened where small farms grow multiple crop types. Lower technology costs and interoperability among different systems can ease efforts to deploy ag tech more broadly.

Background

“The Lord only blesses a farmer with 30 or 40 years, and we can only try things one season at a time.”

<u>*Factors affecting adoption*</u>
Interviews with farmers confirm that internet connectivity supporting ag tech is an integral aspect of improving productivity for corn, soybean, small grains, and other crops. Mobile connectivity is critical to support precision planting and other functions that are tied to equipment that traverses fields (*see* Charge 4 at p.]). These broadband capabilities support such functions as auto steer, precision planting, electric meter drives, and row-by-row fertilizer control. Additionally, various types of data including harvest and sprayer data, combined with data display systems like Climate Field View, can support planning for planting seasons.

As technology development and adoption are promoted, all ag sectors must be considered. Livestock is sometimes overlooked compared to cropping systems, but dairy cattle are very highly managed through technology on the animal and in the milking barn. All of them require some form of wired or wireless data connections to become part of the internet of things (IoT).

Data gathering is critical, particularly when planting on new ground; every acre must be documented as a baseline for future years. Farmers' ag tech enables individualized reports as opposed to commercial soil maps that cannot deliver highly granularized data. Ag tech enables this: One farmer explained: "We used to work in 100-foot widths, we are now working inch-by-inch." Crop applications also include grain drying facilities with wireless monitoring systems, which were originally designed for cellular. These systems are more reliable and capable with wired broadband in conjunction with a static IP address.

Adoption of this technology, however, does not depend solely upon whether the farmer has connectivity. Farmers note the impact of compatible technology on adoption, and decision-making based on using (a) a "closed" system that accepts only its own branded or licensed technology and (b) an "open" platform that enables farmers to mix and match technology products. These products include not only equipment but also sensors that monitor, for example, moisture, soil temperature, organic matter, and cation exchange capacity (CEC), which refers to the soil's ability to supply calcium, magnesium, and potassium.

Other factors also inform a farmer's decision to adopt ag tech, including the age of farmer, size of the farm, and what is being farmed. USDA ERS has published research that correlates size of farm to ag tech adoption.[78] Age of farmer continues to be a factor in adoption, borne out by both academic research and observations by extension officials.[79] One farmer observed, "The older generation don't accept it as much."[80] However, even while farmer age is identified as an issue,[81] that is likely to be self-

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[78] McFadden, J., Njuki, E., and Griffin, T., "Precision Agriculture in the Digital Era," Economic Research Service, USDA, at 18, 29 (Feb. 2023) (www.ers.usda.gov/webdocs/publications/105894/eib-248.pdf?v=1739.1) (visited Sep. 11, 2025).

[79] GAO at 14 (internal citation omitted).

[80] Presentation of Allan Gavin and David Tindal (May 3, 2024).

[81] *See,* Mindy Ward, "How Age of Operator, Farm Size Determine Ag Tech Use," Missouri Realist (Jan. 20, 2021) (https://www.farmprogress.com/technology/how-age-of-operator-farm-size-determine-ag-tech-use) (visited Nov. 27, 2024); *see, also,* Seidemann, J., "From Fiber to Field: The Role of Rural Broadband in Emerging Agricultural Technology," Smart Rural Community, NTCA-The Rural Broadband Association, at 11-13 (Arlington, VA) (2021).

resolving, much the way gaps in broadband adoption based on age are narrowing over time as the "new class" of senior citizens does not abandon technology as it ages.[82]

Technology costs

Pricing of the technology may be keeping some farmers out of the market, particularly when costs may exceed $100,000 to add on to additional equipment. "If you can cut down seed costs, and application costs, it pays for itself – but a lot of guys don't believe it."[83] The return on investment (ROI) for a smaller operation will require a longer recovery time than for a larger farm. Additionally, while productivity gains can often be measured and are easily appreciated, avoided costs may be more difficult to quantify. One small farmer explained that he has two 12-row planters, and that it would cost $60,000 (2024) to update each planter. This would enable him to capture more data, but the question that he confronts is how manageable the expense is against projected ROI on a small farm.[84] He explained that he has been collecting yield maps for more than 20 years and adjusts plantings based on the findings, and that he does not hesitate to try new approaches. Technology costs, however, are a constantly shifting goal line.

Generally, costs for a particular technology decrease over time (by way of example, the price of a top tier Betamax VCR was more than $2,000 when new – an astounding $12,000 in today's dollars).[85] As technology becomes more common, however, economies of scale in production and distribution are realized. At the same time, newer technologies with high initial costs crowd the stage. This ongoing dynamic presents ag tech developers and farmers with a paradigm choice: To create the best technology possible in the expectation that costs will decrease over time vs. making more affordable yet less capable technology. Costs also increase for small farms: A farmer overseeing 100 acres with a diversified crop portfolio will have a difficult time implementing specialized technologies that are geared to individual crops; the economies of scale do not favor small farms. The inability of small farmers with diverse crops to benefit from ag tech is reflected in adoption statistics: Northeast farms are typically small, with multiple crops – and adoption rates in the Northeast are lower than the national U.S. average.[86] These results are consistent with findings presented by

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[82] *See,* "Internet, Broadband Fact Sheet," Internet & Technology, Pew Research Center (Nov. 13, 2024) (https://www.pewresearch.org/internet/fact-sheet/internet-broadband/) (visited Nov. 27, 2024).

[83] Presentation of Allan Gavin and David Tindal (May 3, 2024).

[84] Presentation of Allan Gavin and David Tindal (May 3, 2024).

[85] Dillon Wallace," How Much Did a VCR Cost When it Was Released?" Kodak Digitizing https://kodakdigitizing.com/blogs/news/how-much-did-a-vcr-cost-in-1980?srsltid=AfmBOooyW_J2IEhdBmUt0XqzAjGmm1rdNyFDNaQyIJkWBkWMlJnozVMe) (htd) (visited Nov. 25, 2024).

[86] GAO at 14.

Grand Farm – a consortium of growers, tech developers, and investors – that tech developers must address agricultural diversity and their product's ability to apply to multiple crops in order to make ag tech investments attractive to prospective users.[87]

Costs include not only equipment costs but also subscription fees; the latter may be based on duration of use or per-acre increments.[88] Grand Farm reports that growers find subscription models "undesirable."[89] Lack of interoperability ("fragmentation") also remains a potential barrier to adoption as it can prevent farmers from mixing and matching technology to create customized and affordable solutions.

A farmer's decision to adopt technology might depend on how it integrates with the farm's existing equipment, or whether it implicates redundancies with existing equipment, and whether the value-add of the technology is sufficiently significant to justify the investment. Moreover, surveys indicate that farmers desire integrated platforms across which data can be transmitted and shared.[90] This is not dissimilar to the development of the fax industry in which manufacturers coalesced around common protocols that enabled fax machines from different manufacturers to communicate with each other.[91] Complexity of technology can discourage adoption; technology that requires farmers to manage data collections and analyses are adopted at lower rates than easier-to-implement technologies.[92]

[87] Grand Farm at 6.

[88] *See,* David Fiocco, *et al.,* "Agtech: Breaking Down the Farmer Adoption Dilemma," McKinsey & Co. (Feb. 7, 2023) (McKinsey).

[89] Grand Farm at 5.

[90] "AgTech Trends Survey: Demand Rising for AI, Automation & Data Analytics," Industry News, Precision Ag 101 (Jan. 25, 2024) (https://www.precisionfarmingdealer.com/articles/5708-agtech-trends-survey-demand-rising-for-ai-automation-and-data-analytics) (visited Sep. 11, 2024).

[91] Although the International Telecommunications Union (ITU) released fax machine standards in 1968 and 1976, manufacturers did not manufacture truly compatible equipment until release of the ITU G3 standard in 1980. Engineering and Technology History Wiki, "Fax Machines," (https://ethw.org/Fax_Machines) (visited Sep. 11, 2024).

[92] "Technology Assessment: Precision Agriculture – Benefits and Challenges and Technology Adoption and Use," U.S. Government Accountability Office, at 14, 15 (Jan. 2024) (GAO).

A survey of more than 140 farm equipment dealers reported numerous factors that farmers consider on the road to technology adoption, including:

- Farm income
- Cost of precision ag equipment
- Farm topography and impact on use
- Soil or crop types and potential limits on profitability of using ag tech
- Confidence in agroeconomic data
- Time requirements to analyze and implement data-based strategies
- Data privacy concerns[93]

Dealers also report supply-side barriers, including finding employees who can support their product sales as well as rapid pricing changes that affect sales.[94]

Achieving ROI

The apparent impact of farm size and revenues on farmer adoption can be discerned from the fact that five states with higher rates of precision ag use (Illinois, Iowa, Nebraska, North Dakota, and South Dakota) together account for about half of 2022 U.S. cash receipts for corn (52.6%) and soybeans (45.7%).[95] At the same time, the GAO reports that "Lower adoption rates in the South may be due to the concentration of small, minority, and under-resourced farms lacking access to basic tools such as computers . . . ."[96] The precise contours of capital outlays remain unknown, and one survey correlates high cost of technology and unclear ROI as leading barriers (47% and 30%, respectively) to adoption.[97] Better data analytics could be leveraged to persuade

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[93] Bruce Erickson and James Lowenber-DeBoer, "2022 Precision Agriculture Dealership Survey," Departments of Agronomy and Agricultural Economics, Purdue University, at 22 (2023) (Purdue).

[94] Purdue at 23.

[95] GAO at 13.

[96] GAO at 14 (internal citation omitted).

[97] Fiocco, D., Ganesan, V., de Serrana Lozanzo, M.G., and Sharfi, H, "Agtech: Breaking Down the Farmer Adoption Dilemma," McKinsey & Company (Feb. 7, 2023) (www.mckinsey.com/industries/agriculture/our-insights/agtech-breaking-down-the-farmer-adoption-dilemma) (visited May 23, 2024).

farmers to adopt – but better data requires the use of technology, setting up the classic "chicken/egg" problem.[98]

Farm ROI contemplates not only seed and grain prices but also measuring improvement per acre.[99] Overall, farm ROI can be a difficult hill to conquer, as it must contemplate the blending of various farm crops including seeds and unpredictable weather and insect impacts. Farm management solutions that can crunch the numbers are a growing market,[100] and land grant universities have modeled findings. A researcher at Purdue University is quoted as noting that the amortization of a sprayer can be measured, but that the ROI on other technology like remote sensing imagery cannot be measured until it "drives a decision that provides more revenue for your farm."[101] A study at Auburn University projects 4.3% average cost savings for auto-swath technology.[102] Others, however, advise against relying solely on mathematical ROI estimates and instead incorporating factors that include safety, data management improvements, and the ability of technology to enable rapid response to market conditions.[103] Moreover, difficult-to-measure benefits such as quality of life must be considered. For example, if a farmer can spend less time on farm tasks because of a new technology, that improves the farmer's life as well as the farmer's family's life.

In the interest of maintaining global leadership in food production, assuring farm performance, and achieving savings and efficiencies in water, energy, and chemical consumption, incentives will be necessary to support small farmer engagement with ag tech. Programs aimed at enabling small farmers to access the latest technology will enable the end-user market to drive research and development incentives for developers. At the same time, firms (if they are not doing so already) should be

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[98] See, *i.e.,* GAO at 53.

[99] *See, i.e.,* Schafer, S., "A Simple Checklist to Evaluate ROI on Your Farm," Ag Web/Farm Journal (Jul. 9, 2021) (www.agweb.com/news/business/taxes-and-finance/simple-checklist-evaluate-roi-your-farm) (visited May 23, 2024).

[100] Lennyi, D., Digital Ag: Why is Predicting Return on Investment Per Field so Hard?" Ag Fund News (Jun. 16, 2020) (https://agfundernews.com/why-is-predicting-return-on-investment-per-field-so-hard) (visited May 23, 2024).

[101] Onofrio, M., "The Real Return of Investment (ROI) n Precision Agriculture," Challenge Advisory (Jul. 18., 2018) (https://www.challenge.org/knowledgeitems/the-real-return-of-investment-roi-on-precision-agriculture/) (visited May 23, 2024).

[102] *Id.*

[103] *See,* Hightower, E., "Don't Rely on ROI to Justify Ag Technology Investments, Instead Use These 5 Key Factors," CropLife (Feb. 23, 2024) (www.croplife.com/precision-tech/dont-rely-on-roi-to-justify-ag-technology-investments-instead-use-these-5-key-factors) (visited May 23, 2024).

encouraged to create scaled versions of tech. A variety of incentives may be considered, including tax credits for developers and users and low-interest loans for adopters. Arguably, incentives should be built into the market such that the most efficient technology will create self-perpetuating economic and production efficiencies to drive adoption. Furthermore, business models that include the on-farm application of ag tech by service providers can be helpful to small farmers by enabling the cost of the technology to be amortized across multiple farms.

University extension and research faculty are trusted partners and can replicate cost and productivity modeling faster and more effectively than individual farmers. Extension services can also play a key role in demonstrating the value of ag tech adoption to farmers.

Extension service models can help farmers plot ROI schedules to assess the economic efficiencies of deploying ag tech. Inasmuch as technology costs tend to decline over time, these schedules may be adjusted on a sliding basis to demonstrate projected lower costs over years. State agricultural departments may consider incentives for farmer participation in studies that incorporate ag tech, including but not limited to equipment stipends in exchange for data sharing. It is advisable, as well, to view these recommendations within the context of potential strategies that were explored but found to be less viable. For example, the Work Group investigated whether per-acre incentives could be implemented to encourage adoption among small farmers. However, consultations with state departments of agriculture and university extension services indicated that would not be a viable standalone option. Instead, resources suggested the development of strategies that cultivate enthusiasm and strong dealer support to encourage further adoption by small farmers.

Additionally, equipment manufacturers can consider offering grant-writing support to assist small farmers seek loans, grants, or other funding resources that would ease the financial burdens associated with ag tech adoption. In this model, Manufacturer X would offer assistance to small farm businesses, either individually or in collaboration with a local farm bureau association, seeking public or private funding that the farmer could use to support the farm’s adoption of ag tech. The incentive to the Manufacturer could be an agreement that if an application were successful, the farmer would lease or purchase equipment from that Manufacturer. In a competitive model, multiple manufacturers would compete to offer these services to farmers on competitively favorable terms.

Recommendations

- Federal policies should address affordability of ag tech for small farmers to spur adoption.

- Federal programs should support land grant university research and extension to model and demonstrate ROI strategies, including financial modeling as well as technologies suited to small farms.

Charge 6
Whether any work has been done in this area to date and whether there are lessons from adoption-related efforts in other contexts to apply in the precision agriculture and connected farms context.

Executive Summary

Making comparisons on work done to date confirms the critical importance of multi-sector relationships that has been cited throughout this report. Observing this work has also brought forth additional awareness of how regional differences are not only manifested by geographies and crop choices, but also in attitudes, priorities and culture. The impact and importance of Land Grant Universities and their Extension services are cited repeatedly in this report. However, and perhaps understandably, most of their leadership is exercised in their respective states. Enhancing national or even regional coordination of this leadership could foster greater adoption in states where the benefits of ag tech are not as obvious due to lack of scale or local culture.

Background

Lessons can be learned from both ag and non-ag sectors. For example, in the Northeast, where the country's machine tool industry was born, precision manufacturing brought jobs and community vitality back to a number of New England cities. In Massachusetts in 2006, the Precision Manufacturing Regional Alliance Project (PMRAP) formed between the Regional Employment Boards, three community colleges, the Governor's office and two regional planning agencies which brought access to Federal EDA funding. Today, technology-enabled precision manufacturing is one of the most important industry sectors in Massachusetts and in the Pioneer Valley Region. This multi-party approach between private industry, government, and higher education evidences benefits that can be obtained through creative collaborative ventures.

Healthcare is another example of an industry that evolved to meet a sudden need (COVID) by relying on technology (telehealth) that had been preexisting and now has expanded to greater use (AR/VR as opposed to comparatively video). The COVID pandemic jumpstarted wider adoption of telehealth where coordination among the telecom and healthcare industries created an environment favorable to regulatory actions that sped the expansion of telehealth services. Medicare expanded the scope of reimbursable services during the COVID pandemic.[104] Similarly, partnerships among technology developers, farmers, and policy makers is necessary to "make the case" for policy amendments to speed the deployment of ag tech.

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[104] HHS Fact Sheet, "Telehealth Flexibilities and Resources and the COVID-19 Public Health Emergency," U.S. Department of Health and Human Services (May 10, 2023) (https://www.hhs.gov/about/news/2023/05/10/hhs-fact-sheet-telehealth-flexibilities-resources-covid-19-public-health-emergency.html) (visited Sep. 11, 2024).

Existing farm groups can play a key role in identifying baseline standards of current conditions that can be then compared to other sectors where technology has driven new growth opportunities. States with the highest rates of adoption have important similarities: large farms with an emphasis on commodity crops such as corn and soybeans, a strong extension service and relationships with their land grant universities, and good coordination among farmers, commodity-support groups, higher ed, state government and manufacturers.

Two common observations about differences between high and low adopters are the differences in farm size and crop type. States with the lower adoption rates for Precision Agriculture (PA) technology often face a combination of challenges that hinder widespread adoption. These include smaller farm sizes, limited technological infrastructure, an emphasis on sustainable and local farming practices, economic constraints, cultural resistance, and geographical challenges including topography. To increase PA adoption in these states, targeted interventions such as financial incentives, improved access to technological infrastructure, tailored training programs, and support for small-scale farmers are necessary.

Encouraging collaboration between local agricultural communities and research institutions through regional or national organizations can also help bridge the gap and promote the benefits of precision agriculture technology.

Recommendations

- Federal policies should identify and initiate incentives for the development of ag tech leadership and relationships between the leading adopters and states (or regions) where similar relationships are less robust.

- Federal agencies should create programs and/or incentives for manufacturers to develop deeper product lines that can be applied to smaller farms and non-commodity crops.

- USDA should elevate awareness and understanding of how PA is an essential and expanding tool for farmers and producers for sustainable and even more cost-effective operations.

Charge 7
Metrics that the Commission could apply to measure and track progress towards broadband deployment and precision agriculture adoption on farms and ranches.

Executive Summary

Metrics for progress can be considered in several categories. On the technology side, metrics may include market indicators such as sales, revenues, and profits alongside availability of new technology in the marketplace. On the adoption side, metrics may include surveys of farmers, dealers, and service providers to identify the type of technology and the extent to which it is adopted for plant and animal farming. On the productivity side, progress can be measured by rigorous studies to determine savings in areas such as water, chemical, and labor and other input costs, together with productivity and yield increases.

Background

An oft-repeated aphorism is, “We measure what we treasure.” The drive to develop metrics for ag tech implementation is rooted in common interests of increasing food productivity, yield and security while reducing input costs. Each of these general categories, however, includes data considerations that require measurement and tracking. For example, is productivity measured by total units or units per acre? Are input costs limited to water and chemical applications or do those include employee safety, labor rates and intangible benefits such as saved time that farmers can now spend with family? The collection of these data can rely on numerous approaches including drone and satellite imaging and data acquisition by varied sensors. These data will have incumbent privacy and sharing considerations.

Data collection and its application to the development of metrics is critical as global demand for food increases alongside inflationary forces that affect input costs (including seed, chemical, and labor). Potential long-term changes in weather patterns must also be considered. Each measured value will present a potential intersection with another value, implicating the balancing of interests in achieving the most desired outcomes. For example, a farm might implement ag tech and reduce fertilizer costs. But that reduction must be measured against the overall efficiency of the farm prior to implementation to determine the real value of the investment. At the same time, the value of those reductions may increase as fertilizer costs increase at disproportional rates to farm revenues.[105] The Institute for Agriculture and Farm Policy (IAFP) applies these variables to a so-called MESMIS framework, a method of evaluating sustainability within natural resource systems.[106]

IAFP worked with the University of Minnesota’s Healthy Foods, Healthy Lives Institute to develop and collect food systems data from 50 states over a ten-year period.[107] This project selected 63 indicators from more than 200 to assess economic, environmental,

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[105] *See, i.e.,* “5 Steps to Evaluate Agriculture Technology Opportunities for Your Farm,” RDO Equipment (Apr. 7, 2020) (www.rdoequipment.com/resources/blogs/5-steps-to-evaluate-agriculture-technology-opportunities-for-your-farm (visited Jul. 10, 2024).

[106] *See,* Lopez-Ridaua, S., Masra, O., and Asteri, M., “Evaluating the Sustainability of Integrated Peasentry Systems: The MESMIS Framework,” University of California, Berkley (2008) (https://agroecology.pbworks.com/f/MESMIS.pdf) (visited Sep. 11, 2024).

[107] IFAP at 23.

and other aspects of the food system. Data sources included the U.S. Census Bureau's Economic Census and the USDA Census of Agriculture.[108] The analyses measured relationships among numerous concurrent factors such as stability of milk production, labor demands, investment costs, and availability of milk.

Rational use of metrics will depend on the ability to integrate data from multiple varied sources. Ease of data collection will also factor significantly in the success of implementing metrics-based analyses. Automated data collection will need to be implemented in equipment; stand-alone sensors will require connectivity to enable seamless transmission to network or cloud-based storage. ISOBUS, a standardized measuring system for ag and forestry equipment, could play an important role. The industry standard is intended to support and enable "plug and play" deployment across different manufacturing platforms.[109]

Metrics can be used to measure not only economic success but also progress toward promoting agro-ecological goals including water consumption and reductions in greenhouse gas emissions.

Metrics can include several broad categories such as on-farm and off-farm impacts as well as economic effects relating to follow-on impacts. AI and automation will help with the collection and analysis of expanding types and amounts of data, but consistent data collection will rely on systems whose reporting can be integrated with each other. Overall, the broad scope of metrics suggests the need for interdisciplinary coordination among economists, technologists, and agriculturists. Timelines must also be considered, specifically, whether metrics are intended to define short-term, mid-term, or long-term goals and outcomes.

On-Farm Metrics

The range of metric categories can be expansive; the competing interests of granularity and cost of collection analysis must be balanced. On the farm side, the IAFP lists nearly 30 metrics for on-farm measurement, including:

- Inputs:
    - Non-renewable energy
    - Soil erosion
    - Land use
    - Water
    - Nitrogen fertilizer
    - Pesticide
    - Seed sourcing

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[108] IFAP at 23.

[109] *See,* Martin Fatch, "A Simple Introduction to ISOBUS," CSS Electronics (Oct. 2022) (https://www.csselectronics.com/pages/isobus-introduction-tutorial-iso-11783) (visited Oct. 28, 2024).

    - Weed control
    - Crop management

- Emissions:
    - Greenhouse gasses
    - Ozone-depleting gasses
    - Acidifying gasses
    - Aquatic ecotoxicity
    - Waste production and utilization

- System state:
    - Landscape
    - Natural biodiversity
    - Agricultural biodiversity
    - Air quality
    - Water quality
    - Animal welfare

To these can be added crop yield, crop quality, as-applied map data, and other output indicators. Soil health characteristics can be affected by ag practices and can serve as an important metrics to measure success: 18 of 29 essential plant elements depend on soil quality.[110] Satellite imaging and machine learning can help farmers plot patterns and predict trends over time. The deployment of robots, in addition to creating labor costs savings, can also alleviate fuel costs and equipment wear. Of course, those savings may be counterbalanced by the cost of advanced ag tech systems (which themselves may include subscription and maintenance costs). Automated systems enable accuracy in chemical application. These illustrate the need for a complex system to track data from a broad spectrum of inputs. These metrics can also inform labor and workforce development efforts by defining workplace needs more accurately as technology not only becomes more prevalent in farming but also helps *define* workforce needs in farming.

Data collection will be best implemented when it fits seamlessly with usual on-farm activities. At the same time, trust must be established between the entities utilizing the data and the farmer who eventually relies upon intelligence generated by review of the aggregated data. AI will be critical to data collection and metric building. Useful metrics will need to reflect farm size, crops, regions, climate, and rainfall. Appropriate dataset building will necessitate the balancing and isolation of numerous inputs to create models that enable useful predictive strategies.

[110] "Agricultural Technology Discover Report," Environmental Defense Fund, Environmental Incentives (Mar. 2023).

On-farm metrics also include labor productivity and employment.[111] Unlike soil and crop data, these metrics require personal record-keeping by the farm, though automated systems that track computer, equipment, and other farm tool runtimes can provide an analogue for documented work hours. On-farm metrics can also measure worker safety and reductions of hazardous conditions.

Off-Farm

Off-farm metrics can include information about the economic impact of farming on local and regional communities, including contributions to tax revenues and employment. Off-farm metrics can also measure the propensity of farmers to engage in off-farm work; USDA ERS reports that in 2019, 96% of farm households earned at least a portion of their income from off-farm sources.[112]

On the supplier side, sales of equipment and farm management software can also be invoked as metrics of economic success. In a survey of more than 800 U.S. agribusiness workers, 92% reported that improving on-farm activity will require new data sets. Sixty percent of respondents were planning to increase their ag tech spending in the coming year, including investments in precision ag (66%), farm management software (60%), and data consolidation (45%).[113]

Metrics for success can be measured based on farmed acres, number and size of farmers using ag tech, productivity increases, decreases in inputs (seed, chemical, water). Industry data relating to sales and subscriptions can also reveal market performance.

Productivity gains can also be difficult to measure without the use of counterfactual analyses, as knowable data relating to inputs (such as seed and chemical) and yields are affected by varying weather conditions; measurable rainfall, for example, would be a key input in assessing performance.

Other metric systems can involve more complex approaches. Virginia Tech reports the quantity, Total Factor Productivity (TFP), which measures the impact of land, labor,

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[111] IFAP at 28.

[112] Giri, A.K., Todd, J.E., Litkowski, C., and Whitt, C., "Off-Farm Income a Major Component of Total Income for Most Farm Households in 2019," Amber Waves, Economic Research Service, USDA (Sep. 7, 2021) (https://www.ers.usda.gov/amber-waves/2021/september/off-farm-income-a-major-component-of-total-income-for-most-farm-households-in-2019/) (visited Sep. 11, 2024).

[113] "AgTech Trends Survey: Demand Rising for AI, Automation & Data Analytics," Industry News, Precision Ag 101 (Jan. 25, 2024) (https://www.precisionfarmingdealer.com/articles/5708-agtech-trends-survey-demand-rising-for-ai-automation-and-data-analytics) (visited Sep. 11, 2024).

fertilizer, feed, and other inputs on farm yield. The university proposes “TFP growth can lead to increased competitiveness in the sector through lower production costs.”[114]

For all purposes, data acquisition will need to improve. USDA reports that national adoption rate data for specialty crop and livestock farming ag tech “do not exist.”[115] However, the USDA Agricultural Resource Management Survey (ARMS) has rich data sets on yield maps, soil maps, and VRT, and has used those data to explore ag tech adoption between 1996 and 2019. This provides a ready structure for farmers, government, industrial, and academic researchers to model.[116]

Recommendations

The ag tech industry is encouraged to develop industry standards for interoperability so that data collected by multiple varied devices can be integrated efficiently. Interdisciplinary efforts among technologists, economists, and agriculturalists will be necessary to identify and prioritize categories of metrics. University research and extension efforts can play an important role in supporting this effort. Partnerships among affected industries and interests including labor, water and energy conversation, and rural economic development can also bring resources to support metrics development and implementation.

USDA should establish metrics for progress measured by market indicators such as sales, revenues and profits alongside review of new technology available in the marketplace.

- USDA should work with state agricultural agencies to survey farmers, dealers, and service providers to identify the type of technology and extent to which it is adopted for plant and animal farming.

- USDA should correlate farm productivity data with ag tech adoption and savings in areas such as water, chemical, and labor costs, coupled with productivity and yield increases.

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[114] *See,* “Every Farmer, Every Tool,” College Agricultural and Life Sciences, Virginia Tech at 5 (2023).

[115] GAO at 15, *citing* “Precision Agriculture in the Digital Era: Recent Adoption on U.S. Farms,” Economic Research Service, USDA (Feb. 2023).

[116] *Id.*

Appendix

Chair:

Joshua Seidemann
Vice President of Policy and Industry Innovation, *NTCA–The Rural Broadband Association*

Vice Chair:

J. Alex Thomasson, Ph.D., P.E.
Professor, Department Head and William and Sherry Berry Endowed Chair, Department of Agricultural and Biological Engineering, *Mississippi State University*

Members:

Taylre Beaty
State Broadband Director, *State of Tennessee Department of Economic and Community Development*

Timothy Bradford, Jr., Ph.D.
(representing the Reuben V. Anderson Center for Justice)

Julie Bushell
Chief Executive Officer, Ethos Connected (representing *Irrigation Association*)

Hunter Hook
Managing Director, Communication Banking Group, *CoBank*

Russell Peotter
Senior Advisor, *America's Public Television Stations*

Kevin Royal
Precision Agriculture Specialist, *Clemson University Center for Agricultural Technology*

A: TASK FORCE MEMBERS

Chair:

Michael Adelaine, Ph.D., CIO Emeritus & Special Advisor to the President, *South Dakota State University*

Vice Chairs:

Sreekala Bajwa, Ph.D., Vice President, Dean & Director, *Montana State University College of Agriculture & Montana Agricultural Experiment Station*

Ryan Krogh, Global Combine and FEE Business Manager, *John Deere*

Members:

Andy Bater, Farmer, *Fifth Estate Growers, LLC*

Timothy Bradford, Jr., Ph.D., (representing the Reuben V. Anderson Center for Justice)

Julie Bushell, Chief Executive Officer, Ethos Connected (representing *Irrigation Association*)

Joseph M. Carey, Special Government Employee

Heather Hampton+Knodle, Vice President & Secretary, *Knodle Ltd. Farms*

Steven Hill, President, *Satellite Broadcasting and Communications Association*

Carolyn Price, Executive Director, *Upstate New York Towns Association*

Brad Robison, Chief Executive Officer, Tallahatchie Valley Electric Power Association and Tallahatchie Valley Internet Services, LLC; President, MS Fiber (representing the *National Rural Electric Cooperative Association*)

Joshua Seidemann, Vice President, Policy and Industry Innovation, *NTCA–The Rural Broadband Association*

Joy Sterling, Chief Executive Officer, *Iron Horse Vineyards*

Dan Watermeier, Commissioner, First District, *Nebraska Public Service Commission*

Andy Berke, Administrator, Rural Utilities Service, United States Department of Agriculture, served as an ex-officio, nonvoting member of the Task Force

B: WORKING GROUP CHARGES

PRECISION AG CONNECTIVITY TASK FORCE
Mapping and Analyzing Connectivity on Agricultural Lands
Working Group Charges

The Mapping and Analyzing Connectivity on Agricultural Lands Working Group (Data and Mapping Working Group) shall develop recommendations that will allow the Task Force to fulfill its obligations under the following sections of the 2018 Farm Bill and that will allow the Task Force to measure and analyze connectivity on agricultural lands:

- **12511(b)(3)(A)(i)**: Identify and measure current gaps in the availability of broadband Internet access service on agricultural land;
- **12511(b)(3)(A)(v)**: Recommend specific steps that the Commission should take to obtain reliable and standardized data measurements of the availability of broadband Internet access service as may be necessary to target funding support, from future programs of the Commission dedicated to the deployment of broadband Internet access service, to unserved agricultural land in need of broadband Internet access service;
- **12511(b)(3)(A)(vi)**: Recommend specific steps that the Commission should consider to ensure that the expertise of the Secretary and available farm data are reflected in future programs of the Commission dedicated to the infrastructure deployment of broadband Internet access service and to direct available funding to unserved agricultural land where needed.
- Not later than 1 year after the date on which the Commission establishes the Task Force,[December 4, 2019], and annually thereafter, the Task Force shall submit to the Chairman of the Commission a report, which shall be made public not later than 30 days after the date on which the Chairman receives the report, that details **12511(b)(5)(A)** the status of fixed and mobile broadband Internet access service coverage of agricultural land, and **12511(b)(5)(C)** the steps being taken to accurately measure the availability of broadband Internet access service on agricultural land and the limitations of current, as of the date of the report, measurement processes.

To carry out this charge, the Data and Mapping Working Group shall evaluate:

- Commission broadband deployment data—fixed and mobile—and Department data to identify broadband coverage on agricultural lands;
- In conjunction with the Accelerating Broadband Deployment Working Group, specific steps the Commission should consider to ensure that the expertise of the Secretary and available agricultural land and precision ag technologies data are taken into account in policymaking;
- The suitability of the Commission's and Department's data to appropriately identify and measure current gaps in the availability of broadband Internet access

service on agricultural lands for precision agriculture purposes, and any limitations of the data; and

- Specific steps the Commission and Department should take to improve and/or merge their data to better evaluate and facilitate broadband deployment for precision agriculture, including but not limited to specific steps that the Commission should take to obtain reliable and standardized data measurements of the availability of broadband Internet access service in order to facilitate the targeting of support from future programs of the Commission dedicated to the deployment of broadband Internet access service to agricultural lands in need of broadband Internet access service.

The Data and Mapping Working Group shall annually prepare a report for the Task Force's consideration that, if adopted, would fulfill the Task Force's obligations pursuant to sections 12511(b)(5)(A) and (b)(5)(C) of the 2018 Farm Bill. The Data and Mapping Working Group shall submit its report to the Task Force and Commission staff at least 30 days prior to the date of the last Task Force meeting before the annual statutory deadline.

The Data and Mapping Working Group shall also produce draft reports, separate from or in conjunction with the aforementioned report, for the Task Force's consideration addressing the other topics it has been charged with considering, i.e., topics arising under section 12511(b)(3) of the 2018 Farm Bill, at least annually and shall submit each such report to the Task Force and Commission staff at least 30 days prior to the date of the Task Force meeting at which the Task Force will consider the report.

PRECISION AG CONNECTIVITY TASK FORCE
Examining Current and Future Connectivity Demand for Precision Agriculture Working Group Charges

The Examining Current and Future Connectivity Demand for Precision Agriculture Working Group (Connectivity-Needs Demand Working Group) shall develop recommendations that will allow the Task Force to fulfill its obligations under the following section of the 2018 Farm Bill and that will allow the Task Force to weigh and prioritize connectivity needs throughout its work:

- **12511(b)(5)(B)**: Not later than 1 year after the date on which the Commission establishes the Task Force [December 4, 2019], and annually thereafter, the Task Force shall submit to the Chairman of the Commission a report, which shall be made public not later than 30 days after the date on which the Chairman receives the report, that details the projected future connectivity needs of agricultural operations, farmers, and ranchers.

To carry out this charge, the Connectivity-Needs Demand Working Group shall evaluate:

- Current and future connectivity needs for precision agriculture in terms of coverage, speed, monthly usage, latency, and other factors; the technologies available to meet those needs; and the advantages and limitations of those technologies;
- Whether and how connectivity needs vary by agricultural product, geography, and other factors;
- How and why demand for precision agriculture needs may change over time due to, for example, population increases and shifts, environmental challenges, changes in diets, and increased demand for knowing where food is sourced; and
- Whether the amount or type of connectivity available is or will shift the choices of agricultural producers, for instance from growing one particular crop or crop type to another.

As part of its charge, the Connectivity-Needs Demand Working Group should consider how far in the future to evaluate connectivity needs. It should also contemplate whether different connectivity technologies create a need for or hurdles to interoperability and compatibility between precision agriculture technologies.

The Connectivity-Needs Demand Working Group shall annually prepare a report for the Task Force's consideration that, if adopted, would fulfill the Task Force's obligations pursuant to sections 12511(b)(5)(B) of the 2018 Farm Bill. The Connectivity-Needs Demand Working Group shall submit its report to the Task Force and Commission staff at least 30 days prior to the date of the last Task Force meeting before the annual statutory deadline.

PRECISION AG CONNECTIVITY TASK FORCE
Accelerating Broadband Deployment on Unserved Agricultural Lands
Working Group Charges

The Accelerating Broadband Deployment on Unserved Agricultural Lands Working Group (Accelerating Deployment Working Group) shall develop recommendations that will allow the Task Force to fulfill its obligations under the following sections of the 2018 Farm Bill and that will allow the Task Force to weigh policies and rules to accelerate deployment on unserved agricultural lands:

- **12511(b)(3)(A)(ii)**: Develop policy recommendations to promote the rapid, expanded deployment of broadband Internet access service on unserved agricultural land, with a goal of achieving reliable capabilities on 95 percent of agricultural land in the United States by 2025;

- **12511(b)(3)(A)(iv)**: Recommend specific new rules or amendments to existing rules of the Commission that the Commission should issue to achieve the goals and purposes of the policy recommendations described in clause (ii) (i.e., the bullet above);

- **12511(b)(3)(A)(vi)**: Recommend specific steps that the Commission should consider to ensure that the expertise of the Secretary and available farm data are reflected in future programs of the Commission dedicated to the infrastructure deployment of broadband Internet access service and to direct available funding to unserved agricultural land where needed.

To carry out this charge, the Accelerating Deployment Working Group shall evaluate:

- Policy recommendations for the Commission, the Department, and federal, state, and local governments intended to promote the acceleration of broadband internet access on unserved agricultural lands;

- How the Commission can reduce barriers to broadband infrastructure investment on agricultural lands;

- How the Commission should allocate and license spectrum for the purpose of accelerating deployment to unserved agricultural lands; and

- In conjunction with the Mapping and Analyzing Connectivity on Agricultural Lands Working Group, specific steps the Commission should consider to ensure that the expertise of the Secretary and available farm data are taken into account in Commission policymaking affecting broadband deployment on agricultural lands.

The Accelerating Deployment Working Group shall produce draft reports for the Task Force's consideration addressing the topics above at least annually and shall submit each such report to the Task Force and Commission staff at least 30 days prior to the date of the Task Force meeting at which the Task Force will consider the report.

PRECISION AG CONNECTIVITY TASK FORCE
Encouraging Adoption of Precision Agriculture and Availability of High-Quality Jobs on Connected Farms
Working Group Charges

The Encouraging Adoption of Precision Agriculture and Availability of High-Quality Jobs on Connected Farms Working Group (Encouraging Adoption and Jobs Working Group) shall develop recommendations that will allow the Task Force to fulfill its obligations under the following section of the 2018 Farm Bill and that will allow the Task Force to encourage adoption of broadband and precision agriculture on farms and ranches and thereby address labor supply challenges and promote the availability of high-quality job opportunities:

- **12511(b)(3)(A)(iii)**: Promote effective policy and regulatory solutions that encourage the adoption of broadband Internet access service on farms and ranches and promote precision agriculture.

To carry out this charge, the Encouraging Adoption and Jobs Working Group shall evaluate:

- Whether and how the adoption of precision agriculture, including automated farming, can alleviate problems farmers are facing related to labor shortages and how to further increase demand for technologically skilled workforce in agricultural areas via the adoption of precision agriculture;
- Ways that government, including the Commission, the Department, and state and local governments, can promote adoption of precision agriculture through policies, regulations, and outreach;
- Ways that government, including the Commission, the Department, and state and local governments, can promote community colleges and universities so that they can continue to grow programs in precision agriculture technology;
- Means for government to partner with industry and stakeholders to promote adoption of broadband Internet access services on farms and ranches and promote precision agriculture and its uses to address labor shortages and make available high-quality jobs;
- Obstacles farmers and ranchers face to adopting precision agriculture;
- Whether any work has been done in this area to date and whether there are lessons from adoption-related efforts in other contexts to apply in the precision agriculture and connected farms context; and
- Metrics that the Commission could apply to measure and track progress towards broadband deployment and precision agriculture adoption on farms and ranches.

The Encouraging Adoption and Jobs Working Group shall produce draft reports for the Task Force's consideration addressing the topics above at least annually and shall submit each such report to the Task Force and Commission staff at least 30 days prior to the date of the Task Force meeting at which the Task Force will consider the report.

C: TASK FORCE SPEAKERS

HOW THE RESEARCH & EDUCATION COMMUNITY COLLABORATES TO BUILD AND SUSTAIN REGIONAL AND NATIONAL BROADBAND INFRASTRUCTURE, George K. Loftus, Associate Vice President - Network Services, Internet2

AUTONOMY, SUSTAINABILITY, AND LAST ACRE CONNECTIVITY, Scott A. Shearer, PhD, PE, Professor and Chair, Food, Agricultural and Biological Engineering, The Ohio State University

“THE RULEMAKING PROCESS, FCC Office of General Counsel, Paula Silberthau
PRECISION AGRICULTURE AND DATA TRANSPARENCY, American Farm Bureau Federation, Bernt Nelson

OVERVIEW OF THE U.S. NATIONAL SCIENCE FOUNDATION’S INVESTMENTS IN PRECISION AGRICULTURE AND CONNECTIVITY, U.S. National Science Foundation, Dr. Brandi Schottel U.S. National Science Foundation, Dr. Ellen Zegura U.S. National Science Foundation, Dr. Sudharman K. Jayaweera

FUTURE TECHNOLOGIES SHAPING AGRICULTURE CONNECTIVITY NEEDS, Grand Farms, Dr. William Aderholdt