Connectivity and Edge-computing for Digital Agriculture

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i-FARM TESTBED

Connectivity is critical for Digital Agriculture

Rural broadband connectivity for agriculture can contribute 500 billion USD additional global GDP by 2030

Pandemic-induced shifts to education necessitate e-learning adoption

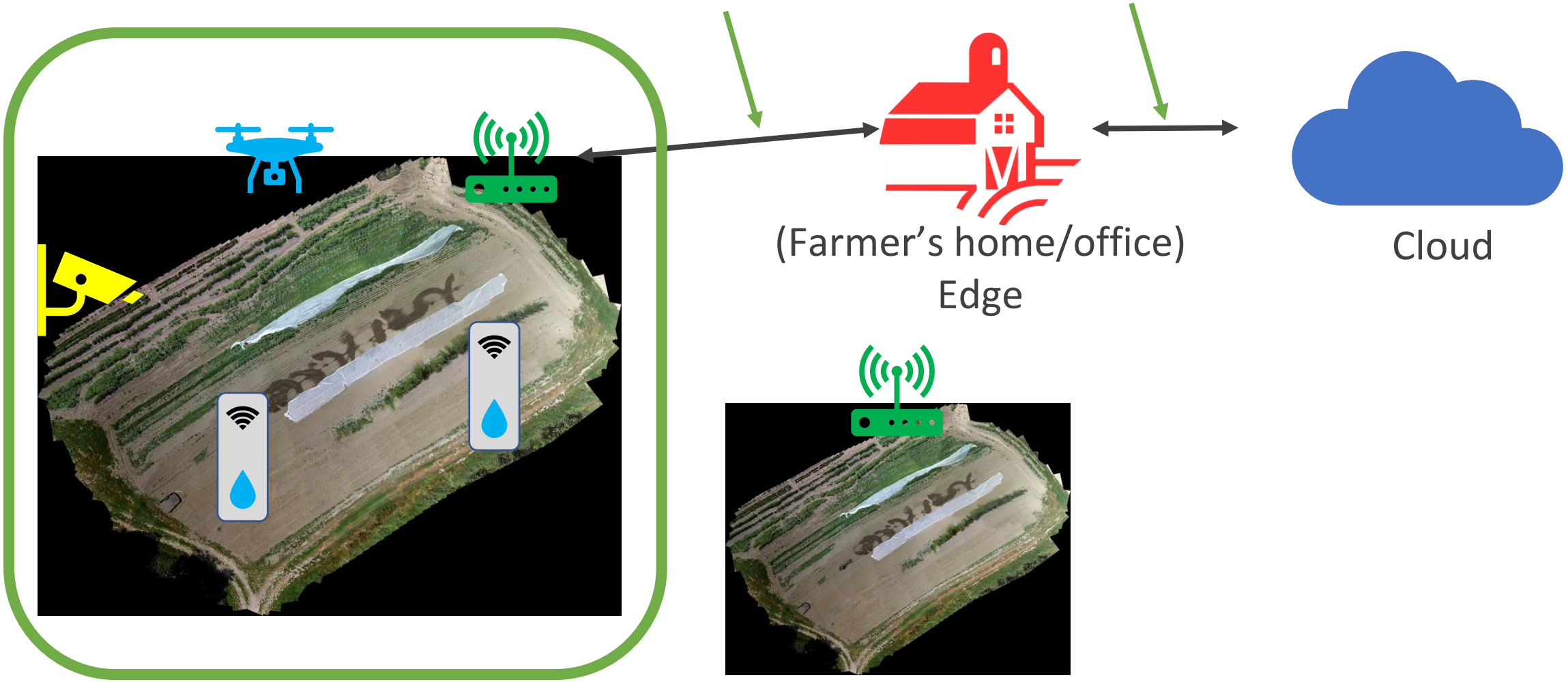
But.. over half the farmers in the US do not have adequate Internet access on farms

Fundamentally, farm of the future cannot be realized without connectivity solutions of the future

Example Applications for Rural Connectivity

- Need continuous connectivity for tele-operation
- Need to stream videos collected on the field for intelligence
- Cannot be supported by rural connectivity solutions today

Farm Network Setup



Applications & Requirements: High Bandwidth Tasks

Sensor	Data Volume	Frequency	Use cases
RGB Camera	50-200 MB per hectare 20 - 81 MB per acre	Multiple times a day	Visual inputs for farmer
Thermal Camera	30 MB per hectare 12 MB per acre	Multiple times a day	Water storage, heat stress
Multi-spectral Camera	1-5 GB per hectare 0.4 - 2 GB per acre	Once a week	Plant health, yield, disease prediction

Applications & Requirements: Realtime Tasks

Sensor	Bandwidth	Latency required	Use cases
Teleoperation	4-10 Mbps	<100 ms	Remote operation for berry picking, virtual walkthroughs
Edge-controlled Robots	10s of Mbps	<100 ms	Complex manipulation tasks like weeding

Connectivity Challenges

Range

- Lower range increases cost and reduces deployability
- Example: Wi-Fi mesh over 100 acres, requires 10-15 devices (200 m range)

Connectivity Challenges

Crops and canopies

- Reduces range and bandwidth
- Effect even higher for below-canopy sensors and robots
- As low as 30m for under-canopy, 5GHz Wi-Fi

Connectivity Challenges

Usability

- Power
- Setup and debugging
- Network management

Connectivity Challenges

	Availability	Long Range	High bandwidth	Mobility
Cellular				
LoRA *Long Range*				
Satellite				
TV White Space				

Our Goal:
Cutting-Edge Connectivity Testbed

New connectivity solutions: Citizens Band Radio Service (CBRS), Satellite networks, Fiber, Low power wide area networks

Edge computing: Dynamically shifting bottlenecks between networking and compute

Data Modeling and Visualization across Modalities: MyFarm app

Current Approach Demands Dense Connectivity

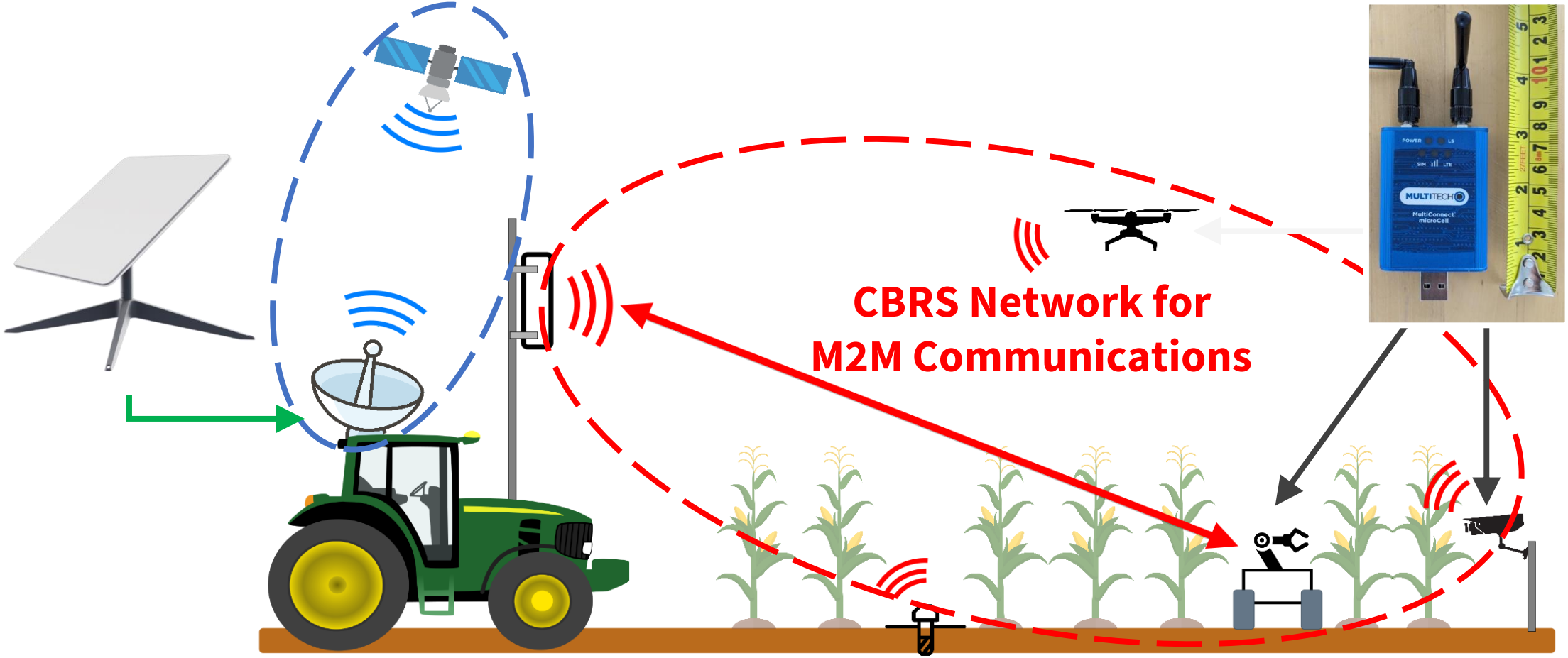
- Needs a dense mesh of cellular networks
- Fiber connectivity costs $10k per mile
- Farms are large (Illinois is 72% farmlands)

Financially not viable for companies to deploy!

Observation:
Sparse demands for connectivity

- Farms need sparse connectivity
  - Only some parts of the farm are actively being worked on
  - The connectivity need shifts to different parts over time
- Example: Tillage and planting activity takes multiple days on a farm
- A farm robot covers about 20-50 acres per day

Idea: Bring your own network

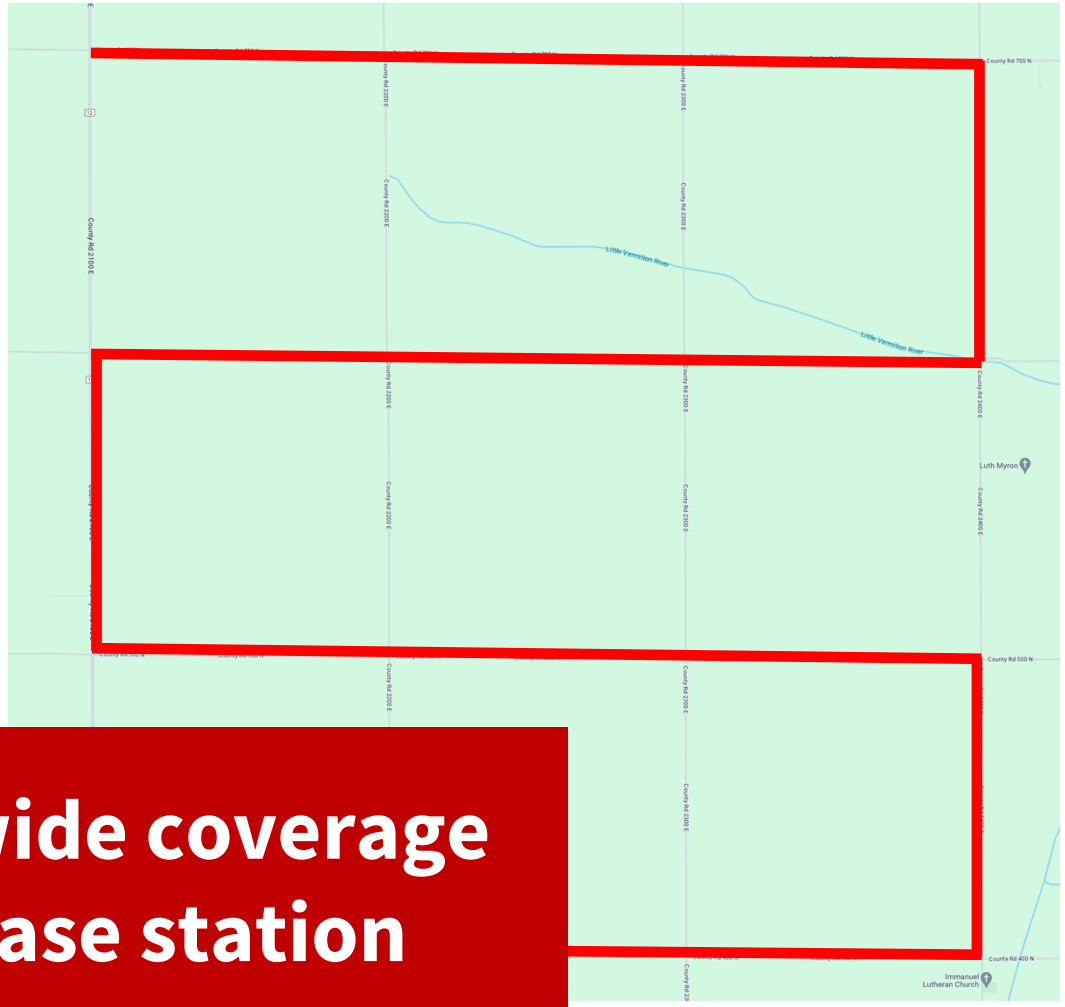


Vehicle for Mobility + Power

CBRS = Citizens Broadband Radio Service
M2M = Machine-to-Machine

Benefits of Horizontal Motion

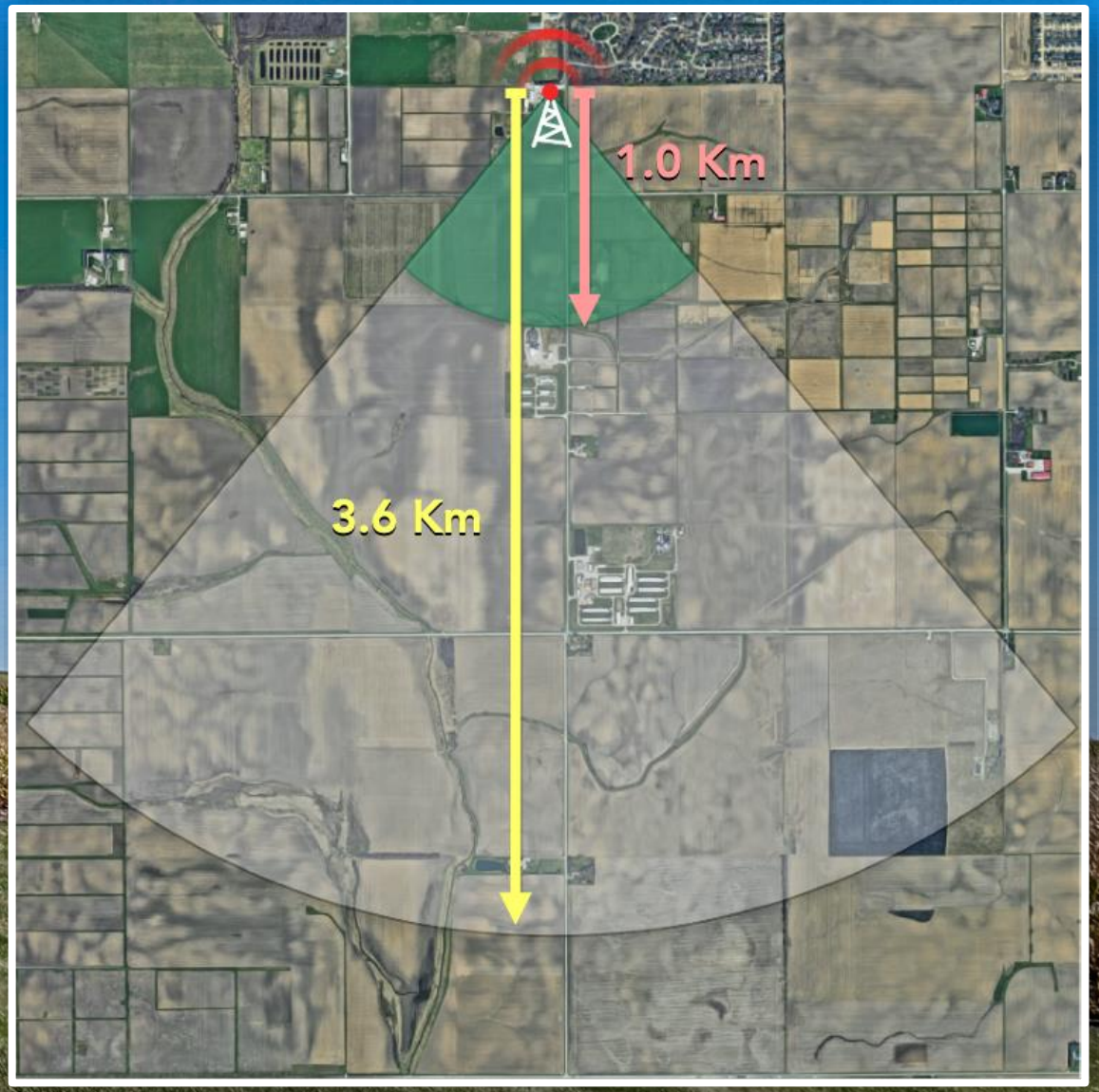
BYON



BYON achieves wide coverage with a single base station

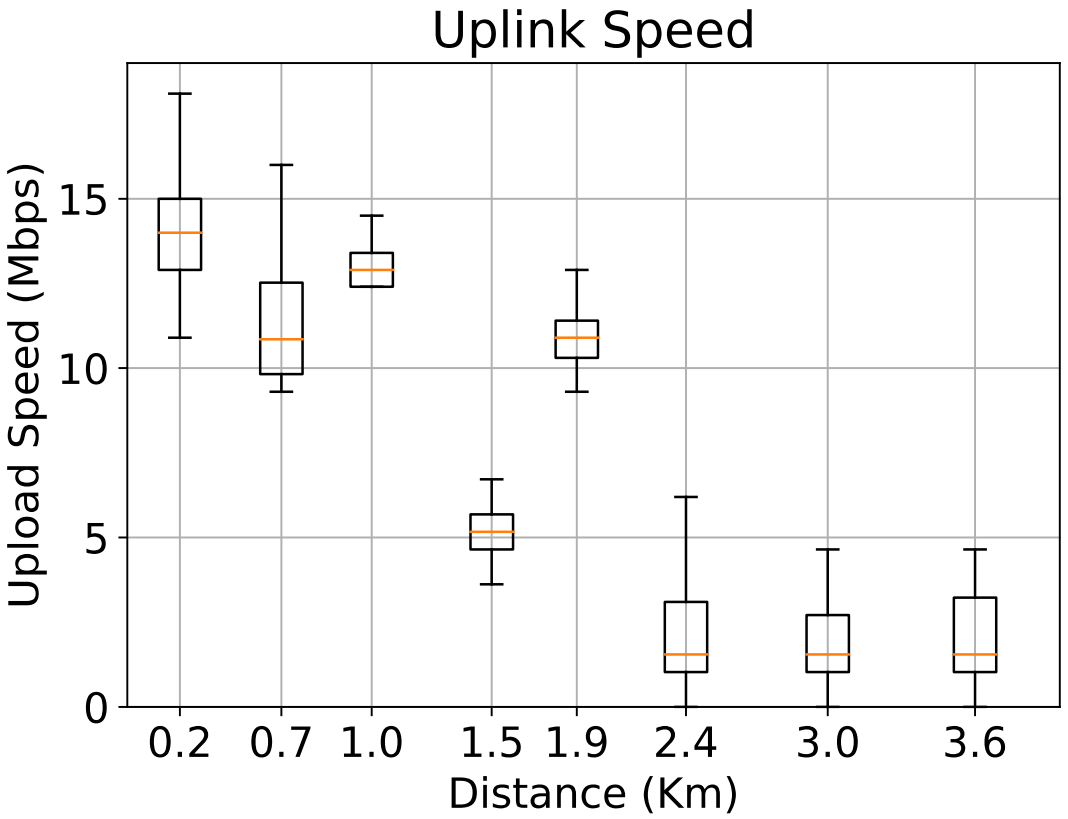
BYON = Build Your Own Network

CBRS Measurements

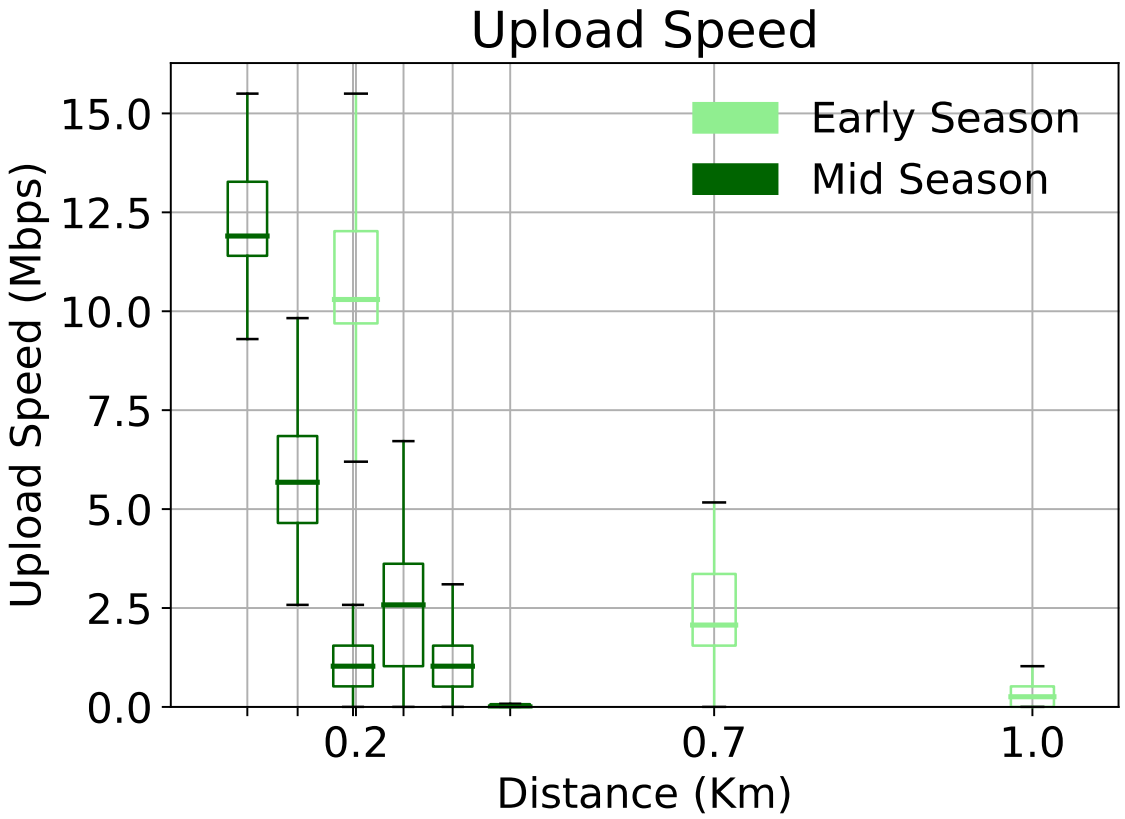


CBRS Measurements

No Crop Blockage



With Crop Blockage



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I-FARM: Farm of the Future

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I-FARM stands for "Illinois Farming and Regenerative Management." This University of Illinois-led study — funded for three years and $3.9M by the U.S. Department of Agriculture's National Institute of Food and Agriculture (NIFA) — is developing an 80-acre agricultural testbed, where commodity crops, cover crops, and livestock are farmed using synergistic, sustainable practices.

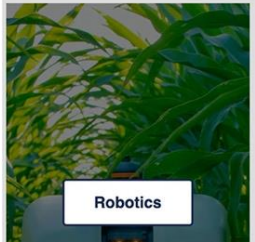
The I-FARM testbed features improved precision farming with remote sensing; new autonomous solutions for cover-crop planting, variable-rate input applications, and mechanical weeding; and artificial intelligence-enabled remote sensing for animal health prediction, nutrient quantification, and soil health.

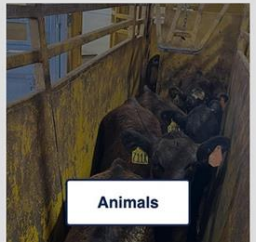
Videos from the field

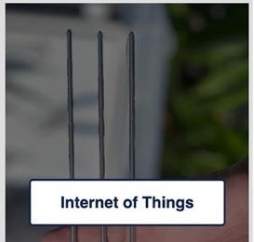
A full I-FARM video playlist may be found on YouTube >>>

I-FARM University: Passing on the knowledge!

I-FARM will demonstrate new technologies, data-driven products, and services for farmers and industry, easing adoption and opening new markets.







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