



Rural Opportunity, ARA PAWR, Research and Community Building

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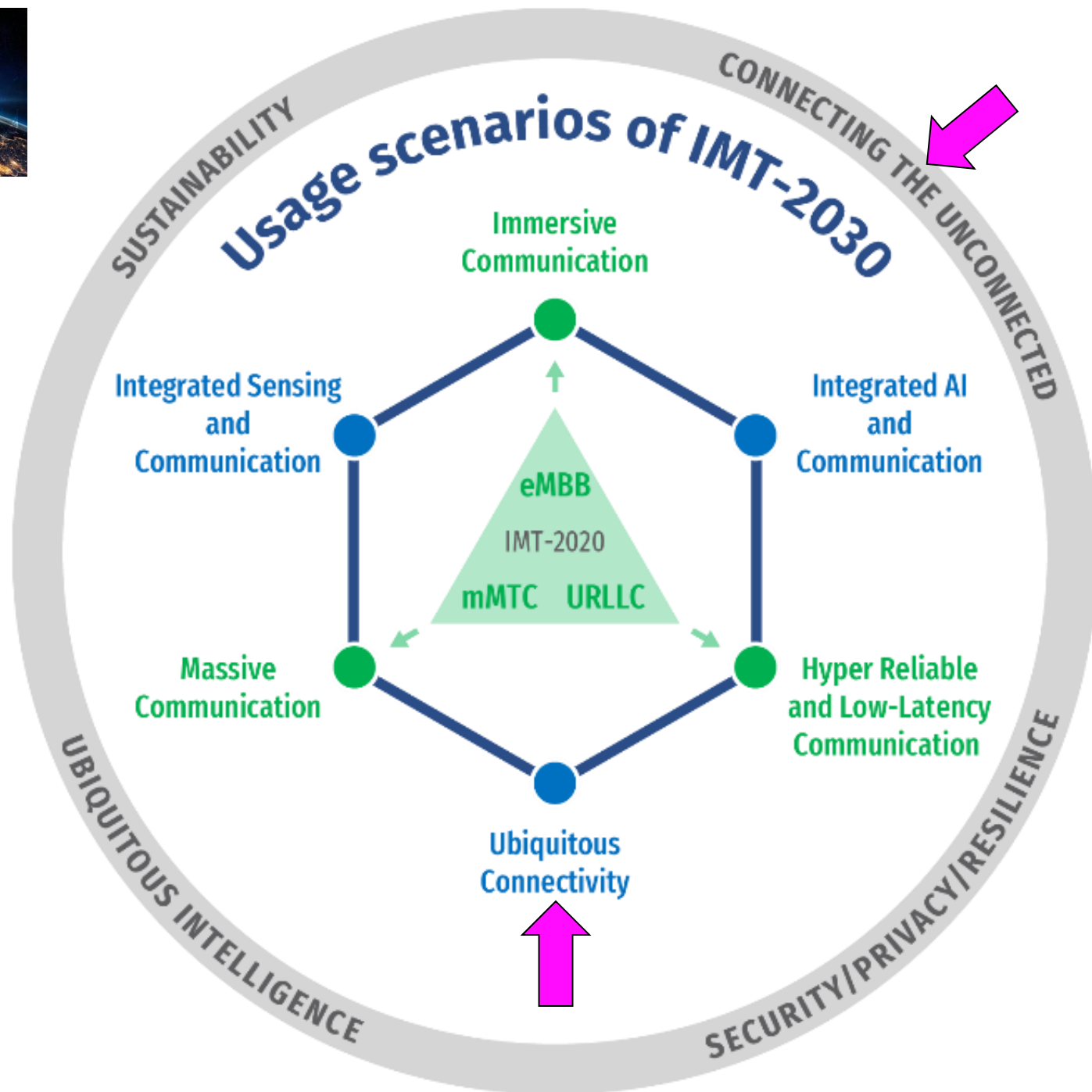
ARA contact: e2@arawireless.org

arawireless.org

IOWA STATE UNIVERSITY
Center for Wireless, Communities and Innovation

UCI
University of California, Irvine



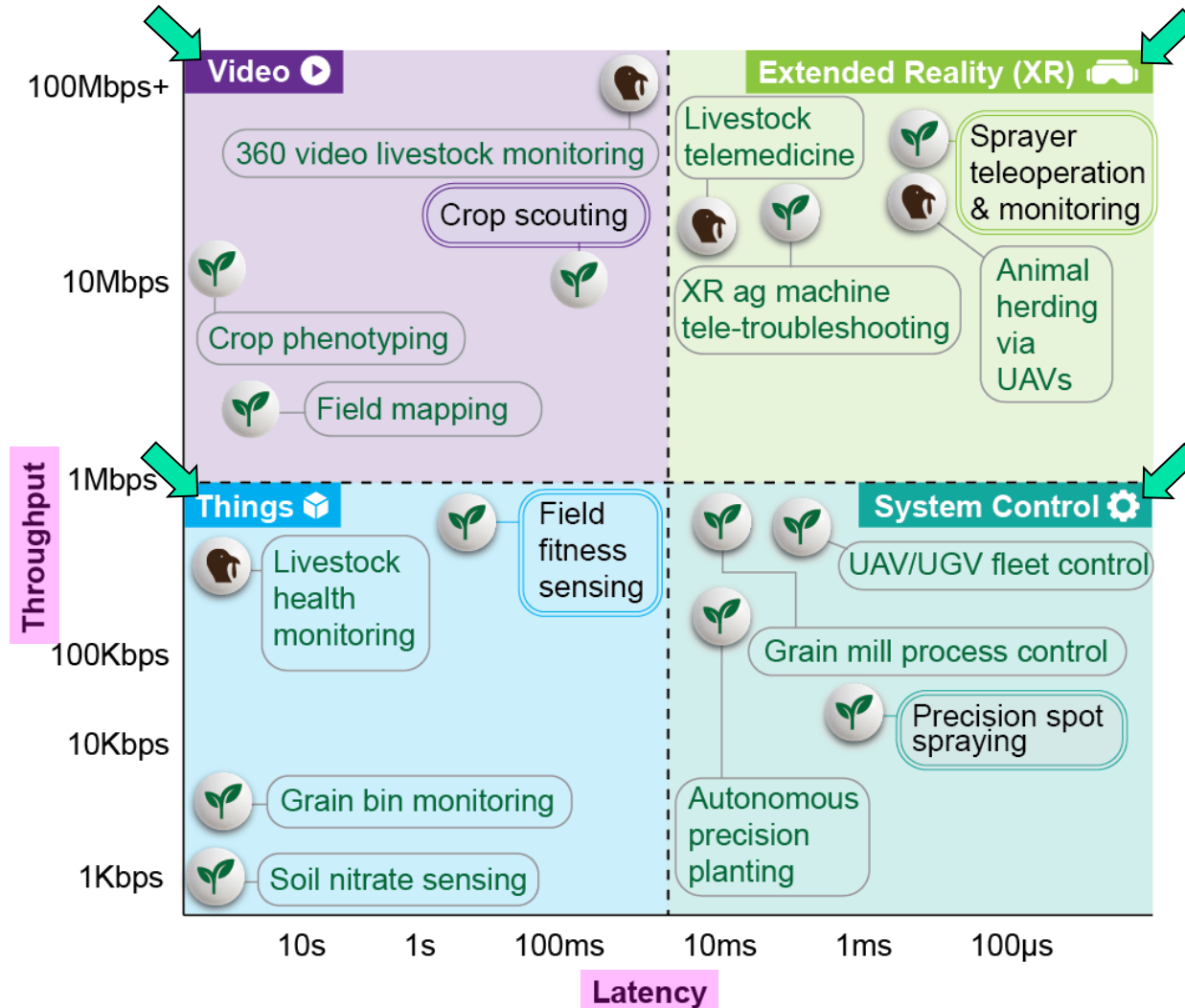


Broadband Divide

- 102+ million rural residents in U.S.
- 3.5+ billion people worldwide
- Most agriculture farms

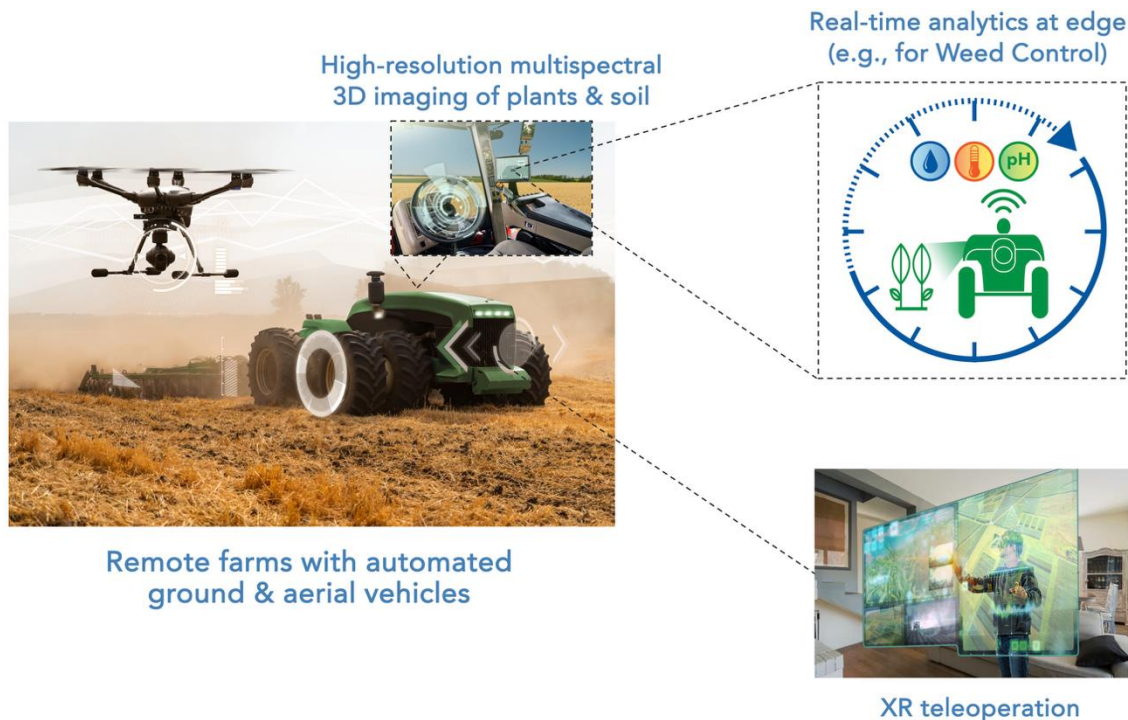
Rural Opportunities

- **Rich, diverse** use cases

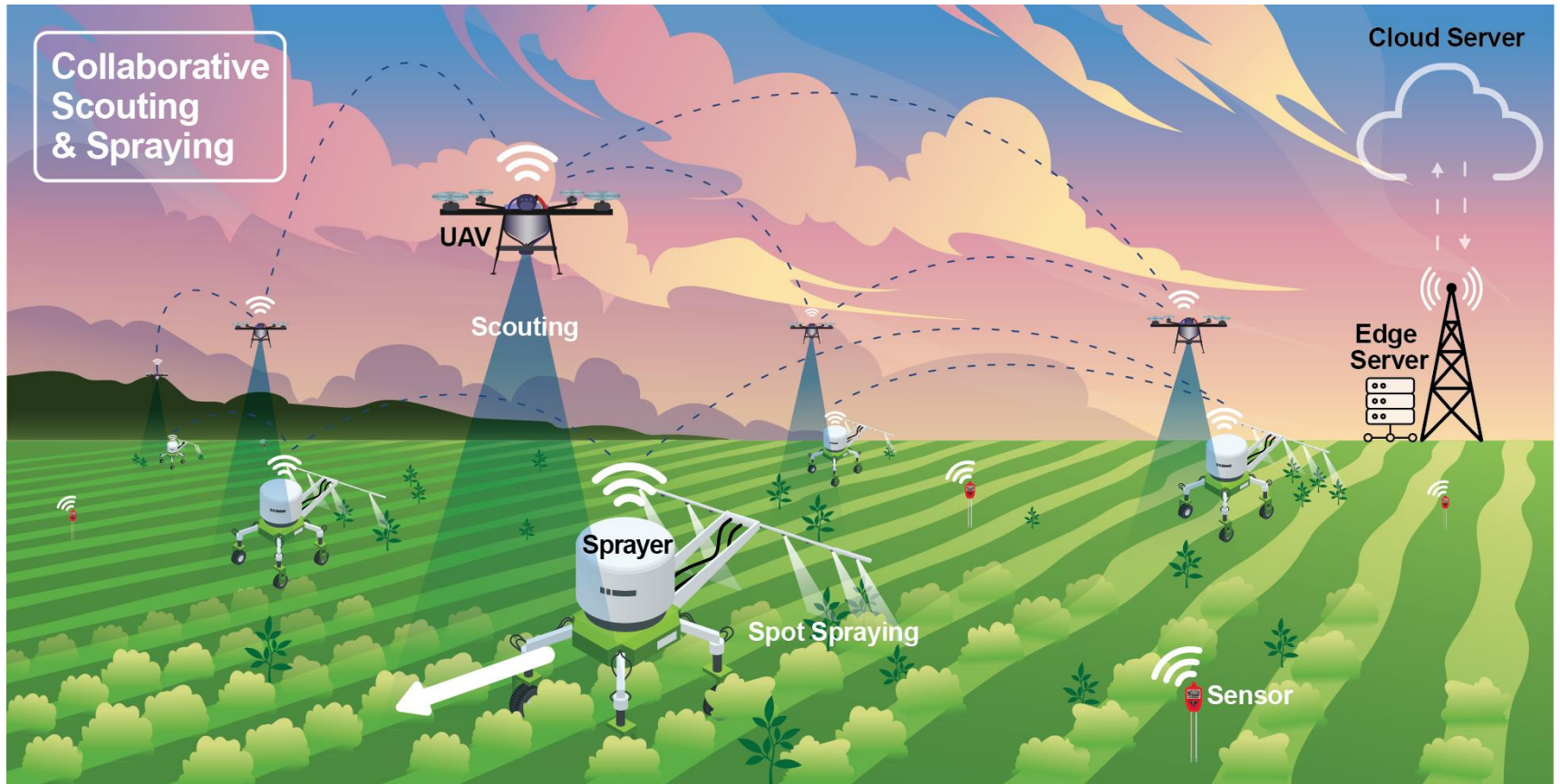


Rural Opportunities

- **Rich, diverse** use cases
- **Rural-first advantage** in application pilot



Precision Weed Control



40–90% reduction in herbicide use

15–25% increase in crop yield

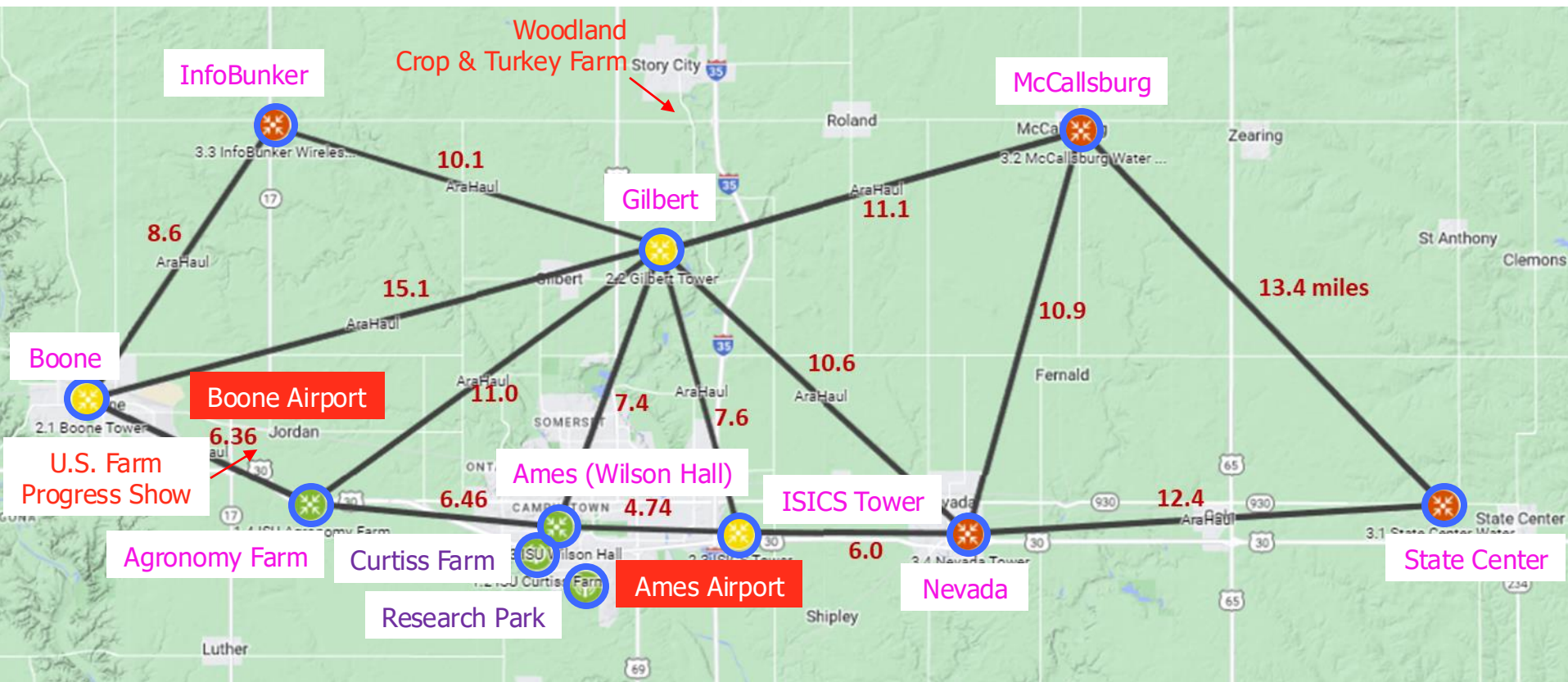
\$18.9B annual benefits globally

ARA Design Principles

- Capturing real-world rural context
 - Deployment & operation
 - Spatial community distribution, community infrastructures
 - Applications: from communities to industries (precision agriculture etc)
 - Economics: factor of 10+ reduction in CapEx
 - Making rural broadband as affordable as urban broadband!
- Fostering wireless & applications co-evolution
 - Programmability
 - Performance
 - Robustness
 - Heterogeneity

ARA Deployment in Agriculture and Rural Settings

 AraHaul mesh sites, each with 1+ AraRANs



 AraRANs around Ames



Collins Aerospace

Long-Distance, High-Throughput Communications

- **AraHaul:** multi-modal, long-distance, high-throughput x-haul

- Terrestrial communications

- Optical (AraOptical)
 - mmWave (Aviat WTM 4800)
 - Microwave (Aviat WTM 4200)
 - Multi-band (Aviat WTM 4811)

194THz	100Gbps+	15km+
71-86GHz	20Gbps	15km+
11GHz	2.5Gbps	20km+
11, 71-86GHz	2.5-20Gbps	15km+
10-30GHz	100Mbps	across planet

- NTN / LEO satcom

- **AraRAN:** high-throughput COTS & SDR systems

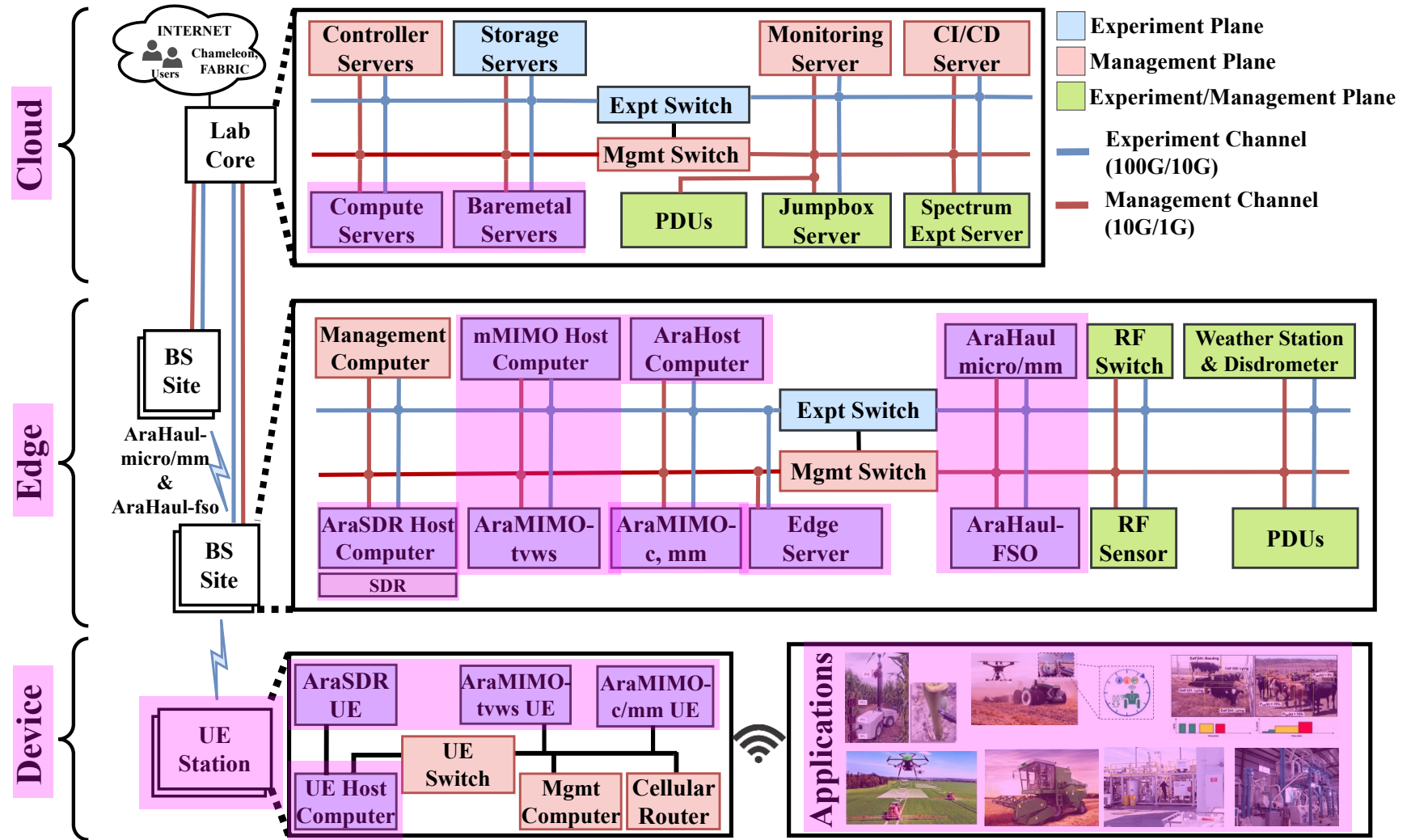
- Low-UHF mMIMO (Skylark)
 - mid-band (Ericsson, NI)
 - mmWave (Ericsson, NI, InterDigital)

460-776MHz	100Mbps+	10km+
3.4-3.6GHz	600Mbps+	4km+
27.5-28.35GHz	2Gbps+	400m+

Diverse use cases

Spectral, temporal, spatial diversity for capacity, real-time, and robustness!

ARA System Architecture

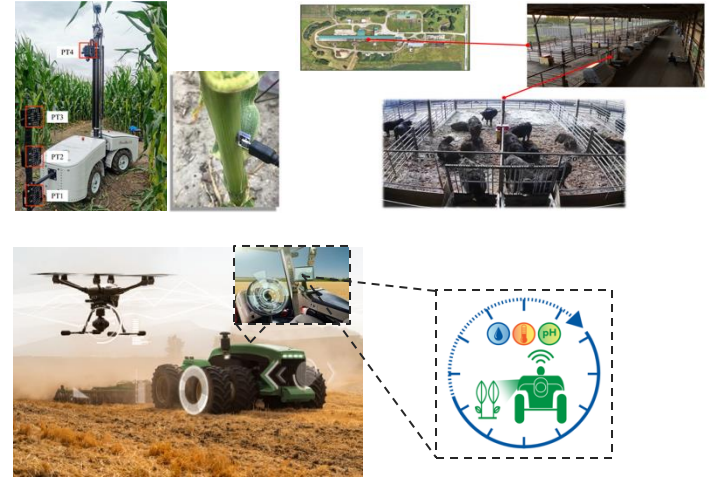


Wireless Research

- Rural channel and link measurement
 - *Long-distance, high-capacity x-haul* at 11GHz, 71-86GHz (& 194Thz)
 - *Heterogeneous access* at 460-776MHz, 3.4-3.6GHz, and 27.5-28.35GHz
- RAN & x-haul systems
 - 5G / NextG, Open RAN
 - mMIMO
 - Spectrum sharing
- End-to-end real-time communications and computing

Applications Research

- Precision agriculture
 - ▣ Crop phenotyping
 - ▣ Livestock health monitoring
 - ▣ Agriculture automation



- Community services
 - ▣ Safe water
 - ▣ Smart transportation
 - ▣ Public safety

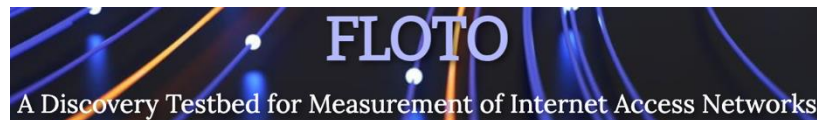


Partner Initiatives

- AI Institutes (NSF, NSF/NIFA)



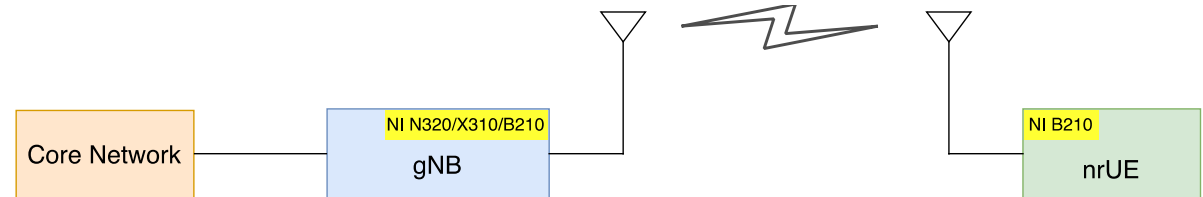
- Community research infrastructures (NSF)



Open-Source 5G and Open RAN



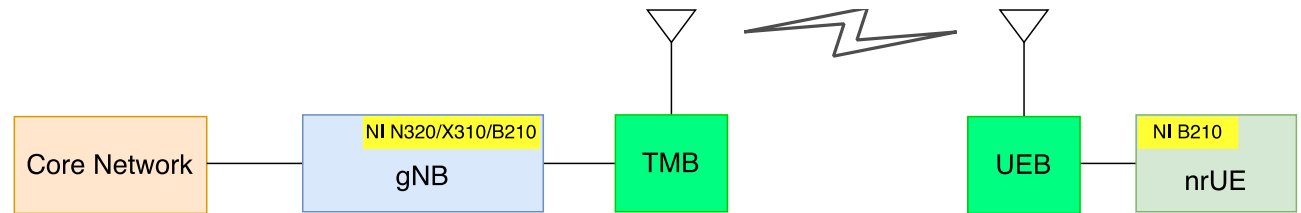
Sandbox



OpenAirInterface, srsRAN, FlexRIC, SD-CORE,
SD-RAN, OSC RICs & SMO



In-Field



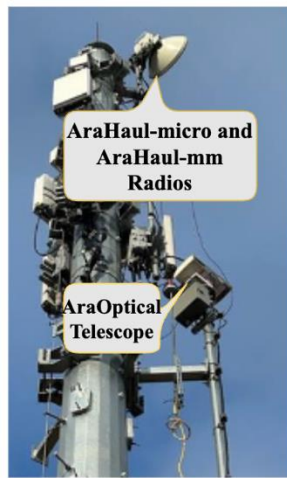
OpenAirInterface, FlexRIC, SD-CORE, **srsRAN**
SD-RAN, OSC RICs & SMO

**End-to-end, in-field & whole-stack 5G programmability
from UE to gNB and core!**

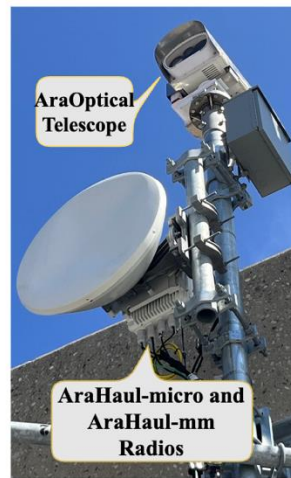
Predictable Per-Packet Reliability Guarantee for HRLLC

- Packet tx. success prob. = $f(SINR) = f\left(\frac{\text{signal strength } (S)}{\text{Interference } (I) + \text{noise } (N)}\right)$
- Predictable control of *probability distribution of* I in **tx. scheduling**
 - ▣ Physical-Ratio-K (PRK) interference model enables predictable, local control despite non-local nature of wireless interference
- Per-packet **tx. power control** for *desired* S based on in-situ I and N

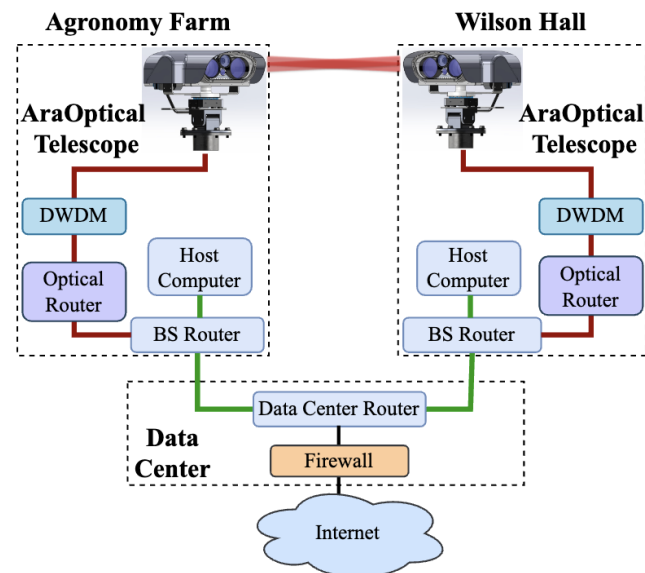
AraOptical: Terrestrial Free-Space Optical Comm.



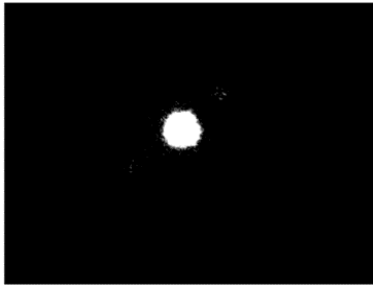
(a) Agronomy Farm



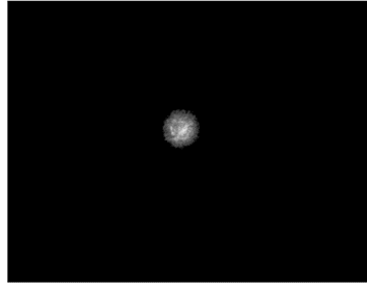
(b) Wilson Hall



Rain Impact: Long-Distance FSOC



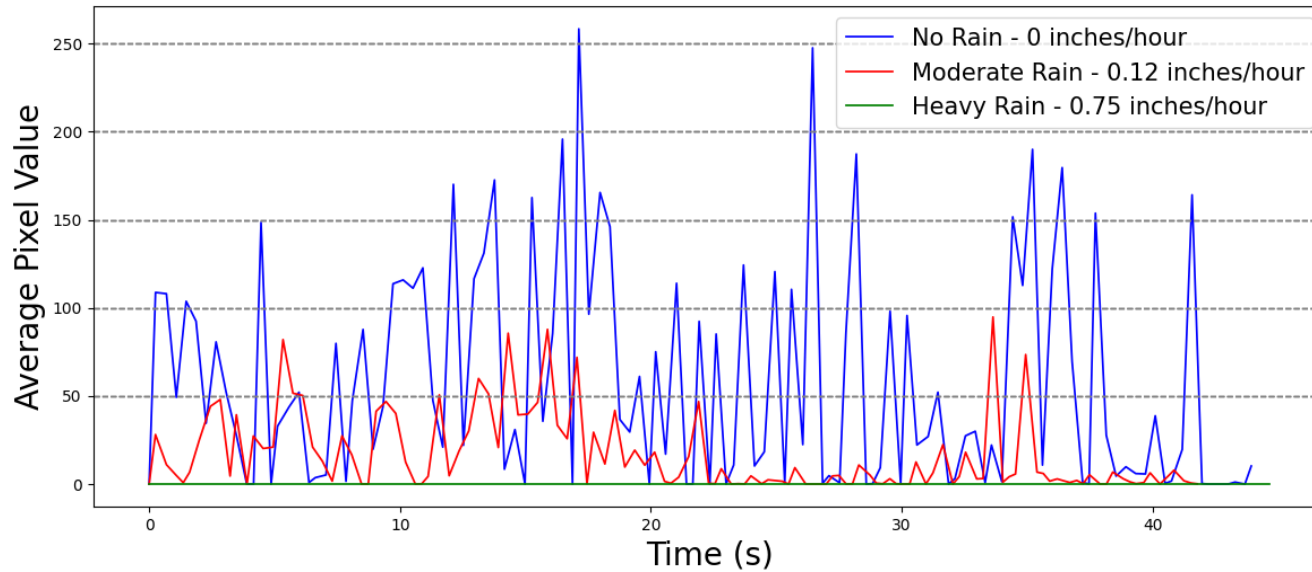
No Rain



Moderate Rain



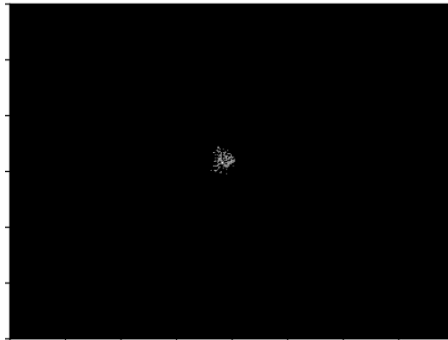
Heavy Rain



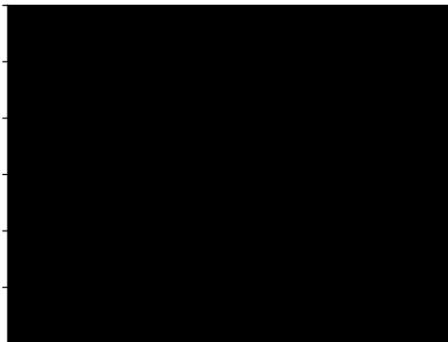
Impact of Rain Rate on FSOC link: CMOS camera output



No Rainfall: Rain Rate 0 inches/hour



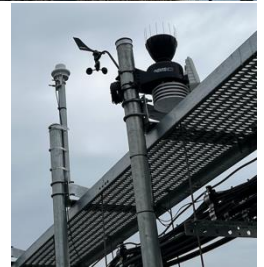
Moderate Rainfall: Rain Rate 0.12 inches/hour



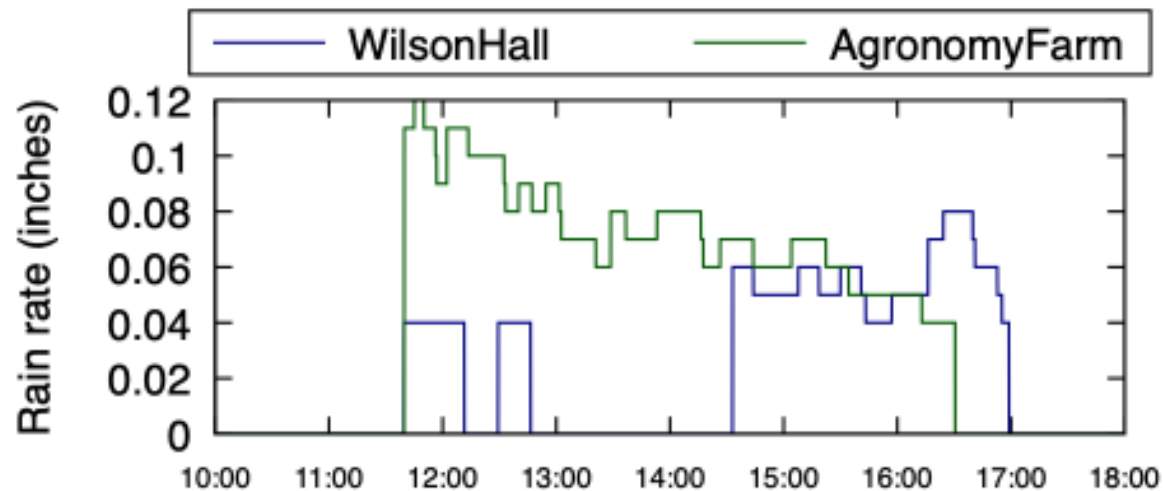
Heavy Rainfall: Rain Rate 0.75 inches/hour

Weather Data & ISAC

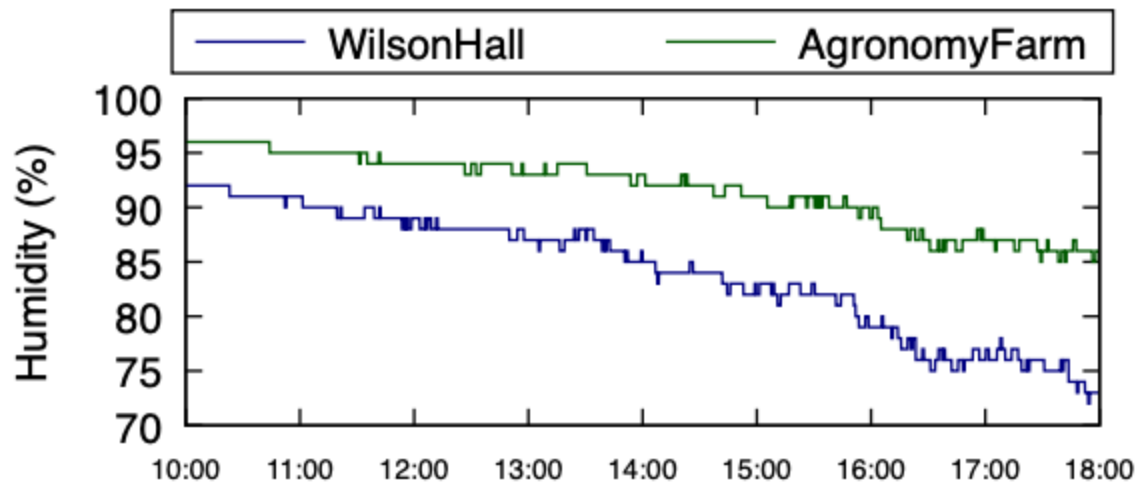
- Precipitation type (rain, snow, hail etc)
 - Precipitation intensity
 - Drop-size distribution
 - Drop velocity
 - Visibility ...
- Wind speed and direction
 - Humidity
 - Temperature
 - Weather code (e.g., haze, drizzle, rain, snow) ...



Weather Spatial Diversity



Time (22nd March, 2024)



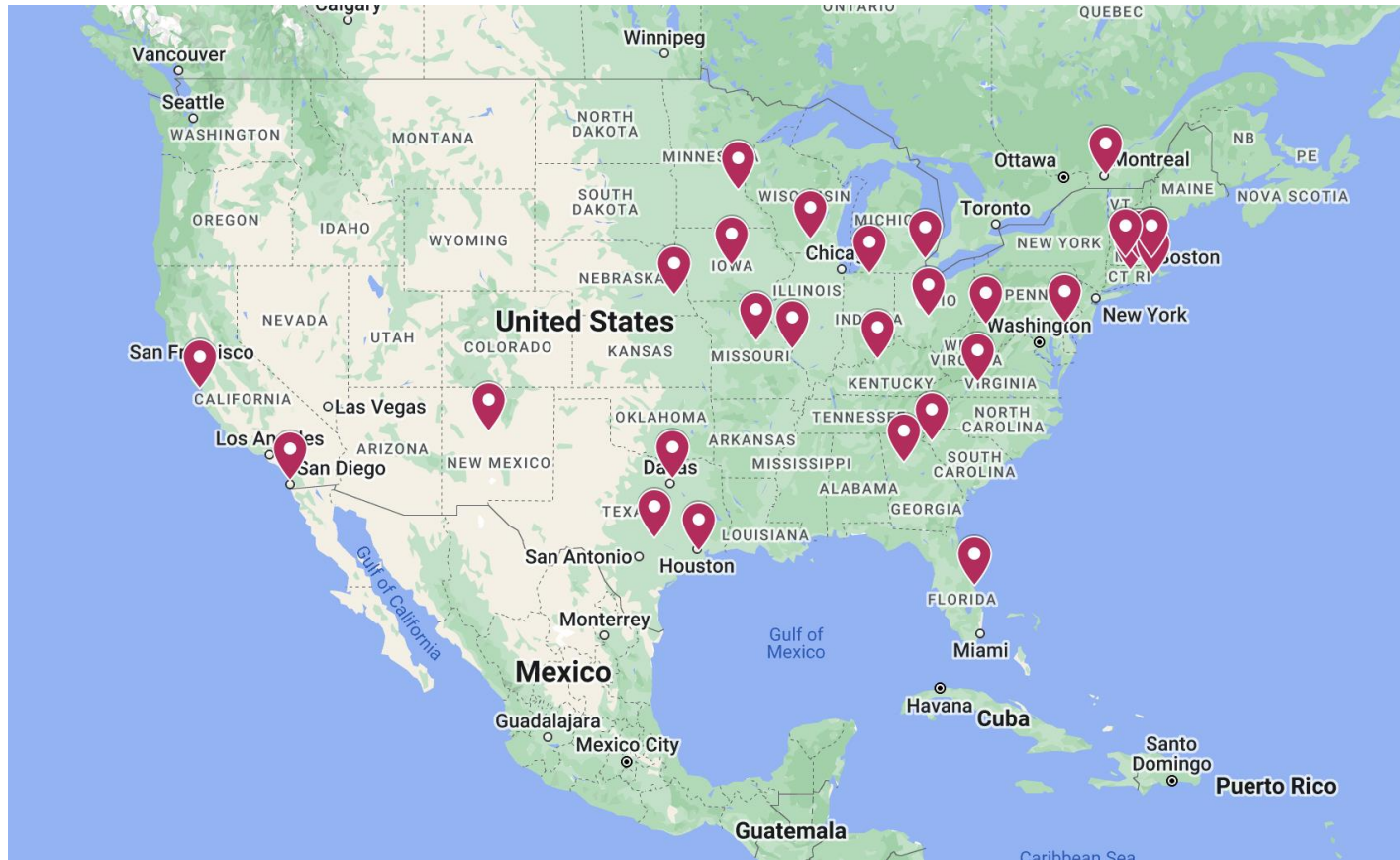
Time (22nd March, 2024)

ARA User Community

Usage Metric	Count
Number of Organizations (e.g., universities, companies)	48
Number of Teams (ARA Projects)	95
Number of Individual ARA Users	319



ARA User Distribution



International Universities: 8

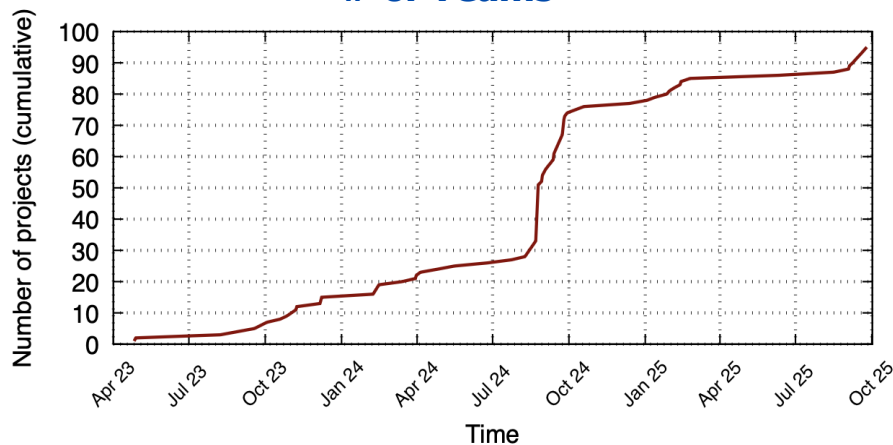
Canada, Brazil

Austria, France, Italy, Sweden

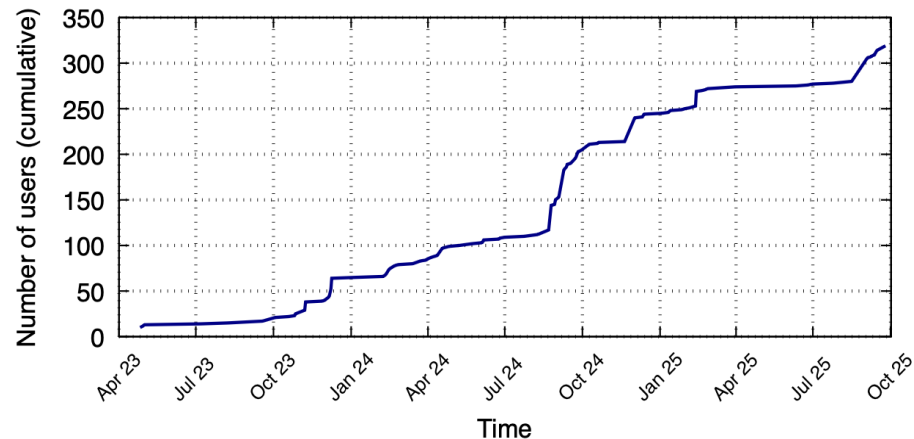
Taiwan, Thailand

ARA Usage Statistics

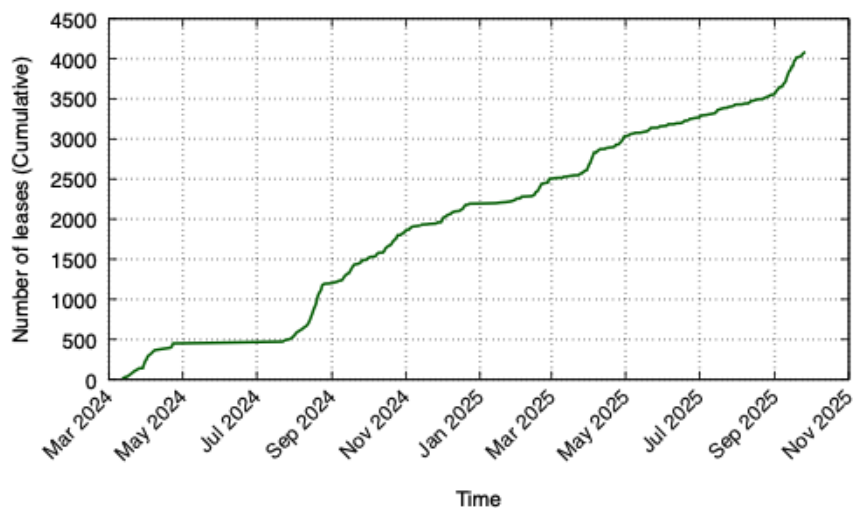
of Teams



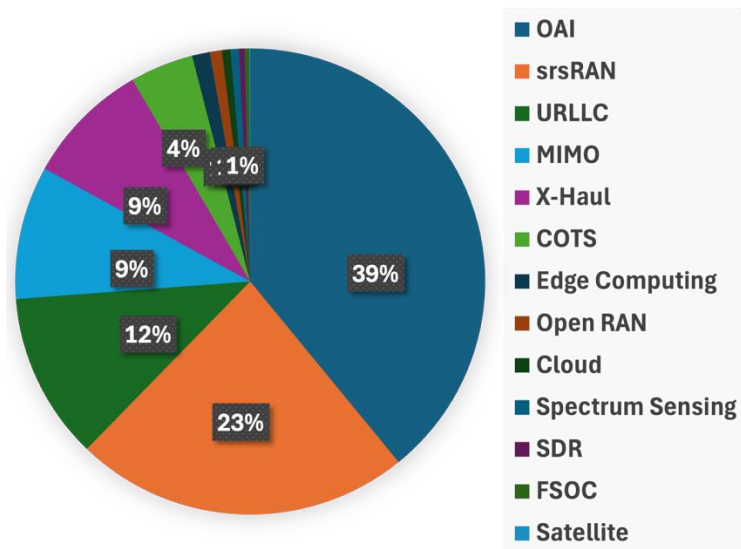
of Users



of Experiments



Experiment Distribution



Call for Participation: Share your Work

| ARA Use In Research

ARA users are invited to share **your publications and your stories** using ARA.

Articles:

1. Joshua Ofori Boateng, Tianyi Zhang, Guoying Zu, Taimoor Ul Islam, Sarath Babu, Florian Kaltenberger, Robert Schmidt, Hongwei Zhang, Daji Qiao, [AraRACH: Enhancing NextG Random Access Reliability in Programmable Wireless Living Labs](#), *IEEE International Conference on Network Softwarization (NetSoft)*, 2025 (**Best Paper Award**)
2. Ahmad M. Nazar, Mohamed Y. Selim, Daji Qiao, Hongwei Zhang, [NextG-GPT: Leveraging GenAI for Advancing Wireless Networks and Communication Research](#), *International Conference on Computer Communications and Networks*, Tokyo, Japan, 2025.
3. Jinwei Zhao, Owen Perrin, Ali Ahangarpour, Jianping Pan, [Measuring the OneWeb Satellite Network](#), *IEEE/IFIP Network Traffic Measurement and Analysis Conference (TMA)*, 2025

arawireless.org/ara-use-in-research

5G in Practice: Measuring Rural Wireless Technology for Edge Devices in Distributed Computation Workloads

September 22, 2025

Authors: Zack Murry (University of Missouri), Alicia Esquivel Morel (University of Missouri), and Kate Keahey (Argonne National Laboratory) Introduction As 5G networks expand beyond urban centers, it is also critical to understand how they perform in rural edge environments, where connectivity can be intermittent and infrastructure sparse. This project, conducted as part of the REU ... [Continue reading](#)

Measuring the OneWeb Satellite Network

June 6, 2025

Authors: Owen Perrin, Jinwei Zhao Prof. Jianping Pan and his team at the University of Victoria (UVic), Canada, have leveraged the ARA platform to conduct studies on low-Earth orbit (LEO) satellite networks. Using ARA's user portal and with support from the ARA team, the UVic team was able to carry out experiments with a Hughes ... [Continue reading](#)

Call for Participation: Action Clusters

- AI/ML
- HRLLC
- Private networks

Overview of Program

- Sept. 27th
 - Community talks
 - ARA for education
 - *ARA tutorials*
 - *Parallel sessions*
 - *Platform-focused use training*
 - *Community-building work session*
 - *Arathon introduction*
 - Field trip
 - Poster & reception
- Sept. 28th
 - Arathon



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