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ENERGY SCIENCES NETWORK

5G Testbed and Wireless Edge for Science

23 June 2022

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U.S. DEPARTMENT OF ENERGY

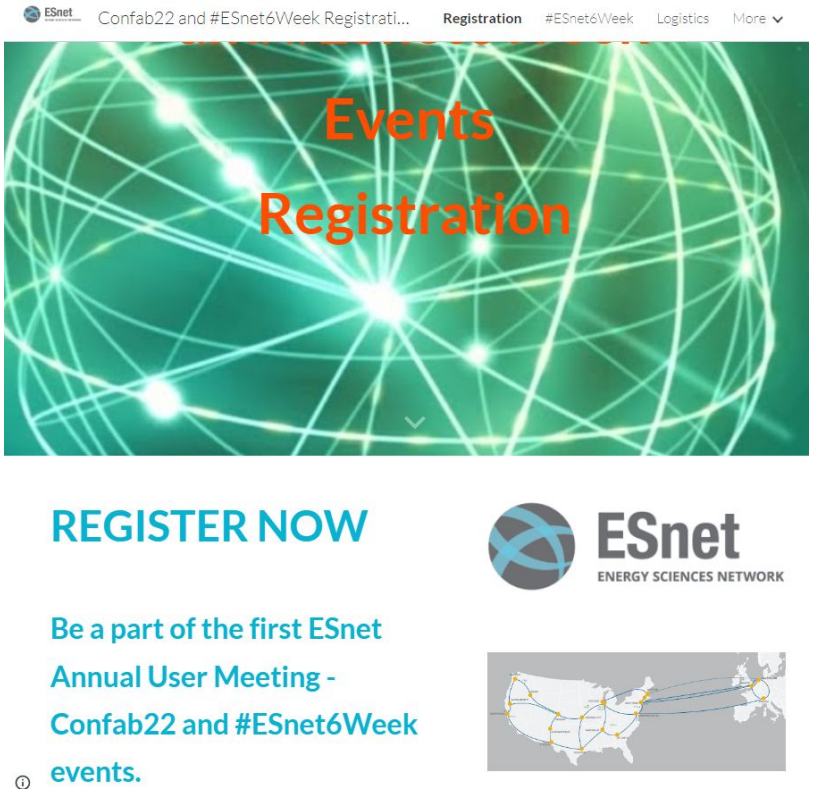
Office of Science

BERKELEY LAB

In conclusion

Register for Confab22 and see you at #ESnet6Week!

https://go.lbl.gov/confab22



Science Motivations

SET is researching how to incorporate 5G/Wireless and better support field science.

1) What are the right support models for scientists engaged in field research?
2) As we “grow into” ESnet6 capabilities, how do we want to posture Wireless for:
   a) Edge compute / HPC backhaul
   b) Intelligent network management
   c) Automation, etc
   d) other….

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Demand Drivers for Science

IoT hardware makes instrumentation cheap, in some cases disposable

Eas(ier) to deploy in all kinds of settings

The entire ecosystem is driven by development requirements that are not related to science (wireless edge/commercial cloud, edge services, ML, API, etc. etc.)

ESnet needs to understand what is coming, develop proficiency, and the capability to modify standards, hardware, and capabilities to meet our science specific needs

- Harsh environments
- Use limitations (EM restrictions, power, weight, etc)
- Get “it” to play nicely with HPC, with workflows, Authentication, Cyber needs, etc.
- Procurement and business models, supply chain requirements, etc

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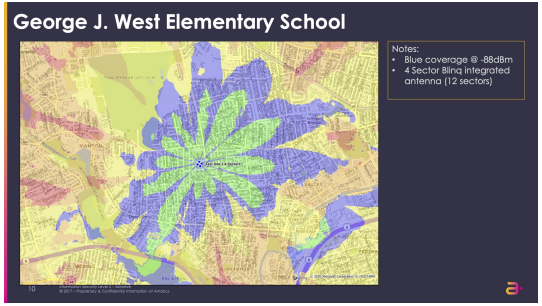
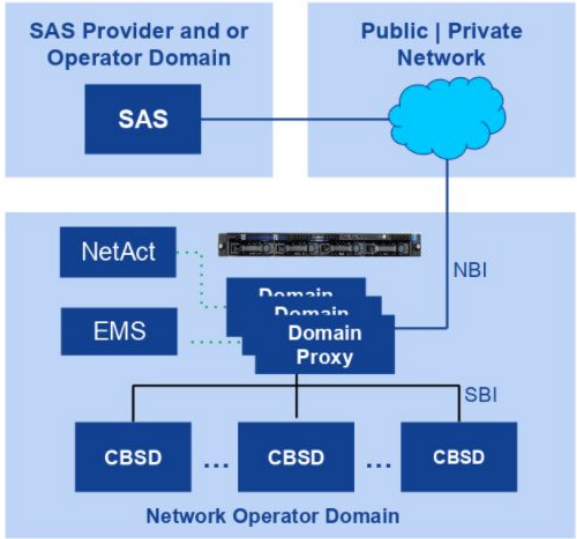
Shared Spectrum & CBRS

- Citizen Broadband Radio Service (CBRS) is a 150 MHz frequency band created by the FCC in 2019 for unlicensed 4G/5G use. **This lets anyone set up a 4G LTE/5G network**.
- CBRS (also called Band 48) is between 3.55-3.7GHz so it has **good internal and external propagation** and range.
- Part of Band 48 is used by US Navy ship radars so Citizens Broadband Radio Service Devices (CBSD) must be enrolled in a Spectrum Access System (SAS)





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Why does this really matter?

Because wireless capabilities are convenient for our customer- and as they become cheap and easily accessible, they will greatly impact all kinds of scientific research programs

If an activity can use wireless (cut the cord) it will. Easier for the user, more flexible

-beamlines at Fermi

-robotic sampling

-etc, etc.

But they will expect that we make it easy to get data back to our optical backbone.

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Learning by doing

Faced with uncertainty, building general capability to track, identify and respond “what is happening” in science use of wireless is the best strategy.

Activities within ESnet:

1) Understanding opportunities for integration of ESnet6/7 Automation and SDN capabilities (Mariam Kiran, Xi Yang, Wenji Wu, Josh Bailey) and Advanced Network Technologies)
2) Understanding how scientists are using IoT and Advanced Wireless (focus of this talk - Science Engagement Team)

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Science Engagement Case 1: urban radiation detection

LBL-NSD Applied Nuclear Physics Program's PANDA project is developing an integrated smart radiation sensor based on ANL's Waggle chassis.

- ML at the edge for multi-mode radiation and context data fusion
- Need to be self contained, wireless, supporting movement of spectroscopic/optical/Lidar data
- Need to operate collaboratively as part of a network
- Working now to deploy several test units at LBL, before hopefully expanding to test in a wider setting

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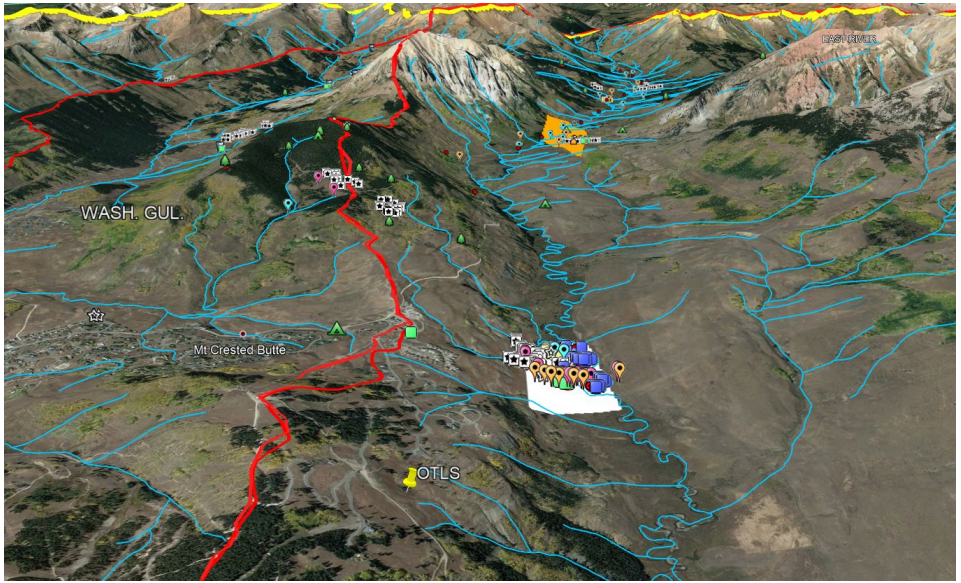
Science Engagement Use Case 2: Env. Field Science in Colorado

1) Sensor fields (in white) covered by CBRS antenna/base station placed near Mount Crested Butte SAIL X-band radar site (marked in yellow).
2) Sensors connected either through cellular directly, or via 1-2 solar cellular-wifi routers deployed by this project in the sensor fields.
3) Backhaul at the SAIL radar site through fiber and Starlink terminals (in collaboration with Starlink)



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Efforts this Year at home

Deployment of our ESnet NDAC Core at LBL, with a remote BBU/RH serving in CO.

+Lets ESnet test operation of a multi-site c service supporting field science

+Improves coverage for sensors at WFSFA

+Allows exploration of integration and fielding challenges with LoRA, Starlink, mmWave and other related technologies

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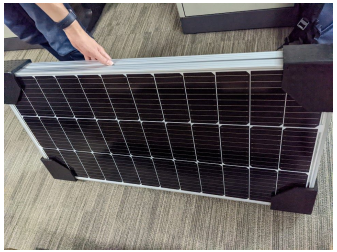
Efforts this year away…SAIL in CO



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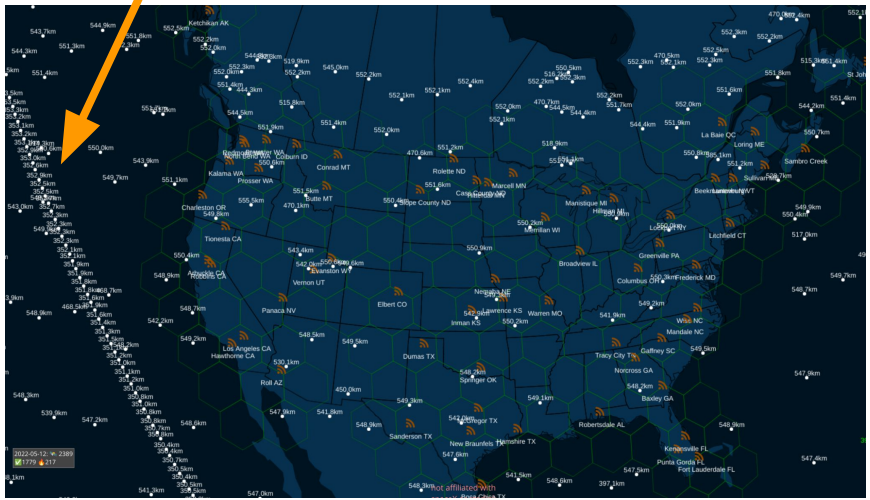
Starlink

- Procured 3 MT, and deploying in CO to provide CBRS backhaul
- Working on peering and ensuring high quality connections to ESnet as DOE/Science use grows
- CBRS backhaul of mutual interest, as some telcos begin to use CBRS to support remote area build-out via Starlink as well. Many interesting lessons to learn.

This blows my mind



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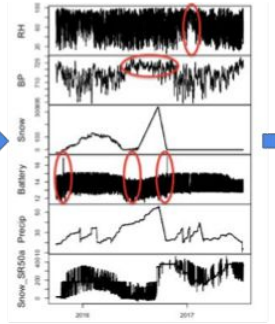
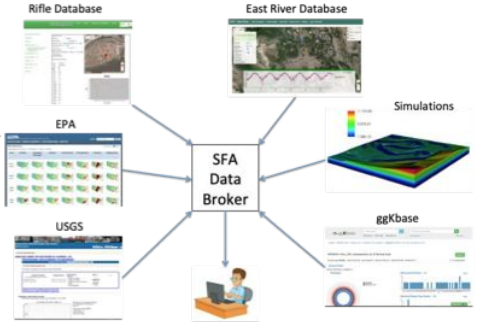
Initial Workflow

(a) Sensor Network Acquiring 100+ Variables x 50+

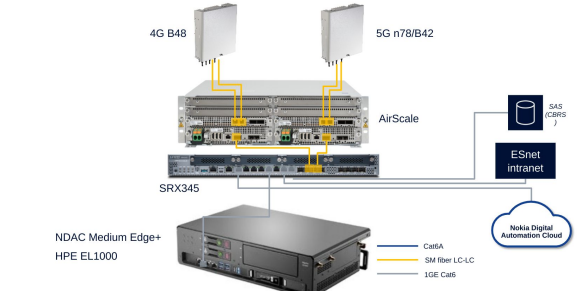
(b) Telemetry and Storage into a Queryable Database

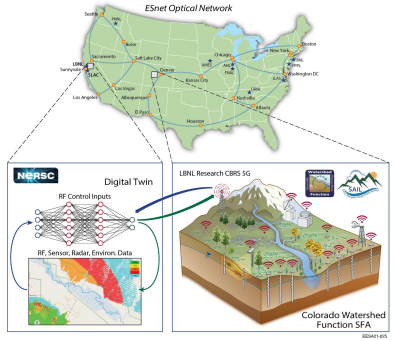


(c) Semi-Automated QA/QC Algorithms



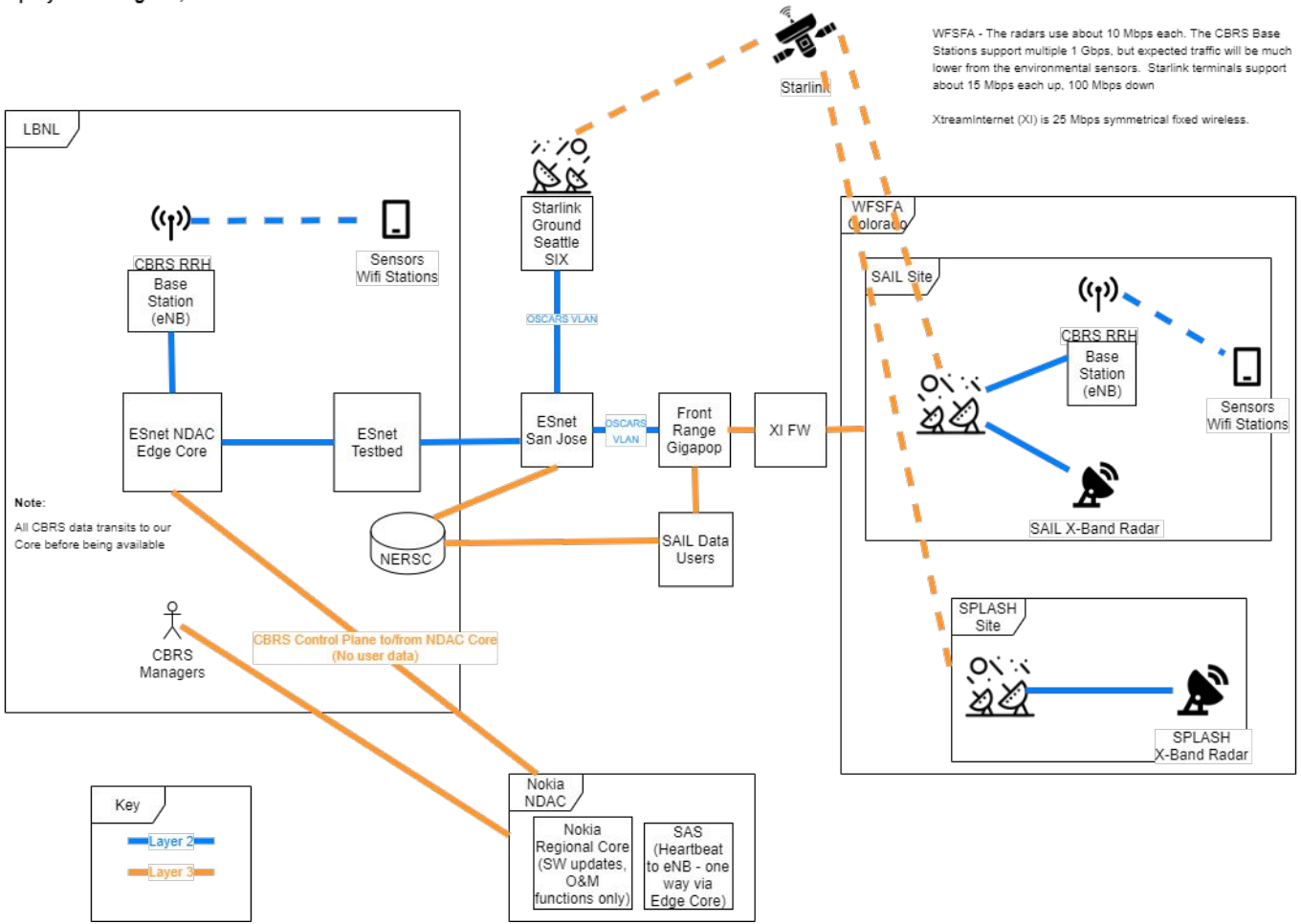
(d) Diverse Data Integration with External Sources via BASIN-3D Broker





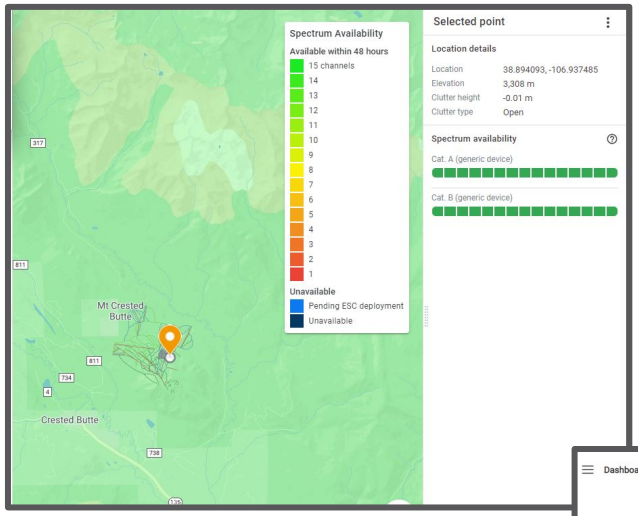
Adapted from Varadharajan et al, IEEE (2019) and Hubbard et al, VZJ (2018)

ESnet CBRS Testbed & Watershed Function Science Focus Area (WFSFA) Colorado Deployment Diagram, 10/22/21

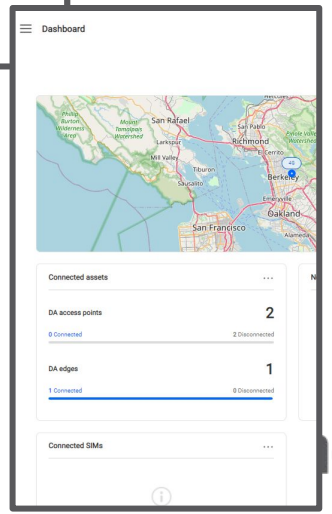


Management

A developing infrastructure exists to manage distributed radioheads, either at the distributed radiohead level, and to predict performance/spectrum availability.



Or to manage a deployment once in operation.



Deployment Schedule

- Radiohead and WFSFA Base deployed in CO and initial sensor connectivity with ARM/SPLASH: July 2022
- Summer sensor connectivity campaign, network adjustments: August 2022
- Full Operation (year to year): October 2023

FY22: SFA Data Team to work with ESnet on data backhaul to NERSC and scope storage, integration with existing SFA data infrastructure

Getting into wireless: subsidiary efforts

Lots of lessons being learned/in process of being learned

1) Lots of small “telco” differences in little things
   a) DC power reliance, PTP to our racks….
   b) Plugs, differences required for equipment weather hardening
   c) Getting folks comfortable with managed HW inside our racks
   d) Design for deploying in resource sparse conditions - USGS/Science COE have been really helpful here
2) Supply chain issues very frustrating….just mentioning for therapeutic value
3) SAS training, operational onboarding of our NDAC system/management
4) Coordinating with other DOE CBRS deployments…beginning to think about the basics (roaming, interoperability, performance monitoring and measurement)
5) Bringing the community along the “shared spectrum” journey
6) Working peering with Starlink, longer term research interests using non-terrestrial networks

Service model(s)

- Providing information - a wireless section on fasterdata, etc
- Providing performance support - perfsonar, network monitoring, etc
- Providing a design model - ScienceDMZ but for wireless deployment or wireless integration with DTN
- Providing wireless access services - helping to deploy CBRS/federate with our systems, interconnecting with new services, troubleshooting and consulting
- Providing wireless access - extending our CBRS system/other systems we may deploy out to the field to support a science campaign
- Providing/enabling edge compute services - smart sensor deployment “go-packages”

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