COWs, COLTs, and Aerostats for Emergency Distance Learning and Telemedicine Broadband Connectivity in Rural Areas

Prepared by Robert Tse, USDA Rural Development, Co Authored by David Witkowski and Mo Shakouri -Joint Venture Silicon Valley; David Espinoza - Chico State University, GIC and Glenda Humiston - University of California Agriculture and Natural Resources, April 2020[i]

In California there have been a series of state broadband meetings focused on the need to provide an immediate response to fill the distance learning and telemedicine broadband access gaps to unserved rural households sheltering in place during the COVID-19 crisis. Some telecommunications providers and public libraries are offering free Wi-Fi hotspots with 4G service to take home; however, 4G hotspots only work in areas with cell phone service.

A lack of broadband, primarily in underserved and unserved rural areas – but also in underserved and unserved urban areas, creates a significant challenge for some U.S. residents in that they are unable to telecommute, engage in distance learning, or use telemedicine.

This challenge can be met by using existing commercial technologies applied in creative ways. Variations in terrain, available resources (siting, power, and backhaul), and served user density require that each solution be engineered for the need, but by using proven commercial technologies we can adjust as needed to balance for performance, cost, and user density.

COWs (Cell-on-Wheels), COLTs (Cell-on-Light Trucks), and Aerostats (CCAs) can be used to provide the cellular or Wi-Fi connectivity in areas without 4G. They are used to provide emergency communications during catastrophic events such as fighting forest fires in rural areas or aftermath of earthquakes. This could be funded through emergency measures including the Coronavirus Aid, Relief, and Economic Security Act (CARES Act).

Questions to Consider

- Could Cell-on-Wheels (COWs) or Cell-on-Light Trucks (COLTs) be set up on an emergency basis to provide distance learning connectivity to students (K-12 and college) during school closures?
- What would be the deployment challenge?
- Would the COWs/COLTs provide the needed broadband connectivity over the widest unserved areas?
- Where would COWs/ COLTs be deployed?
- What are other means of providing immediate broadband connectivity?
- Could the COWs/COLTs provide access for telemedicine management of COVID-19 patients?
- The use of county fairgrounds as emergency hospital locations which require high level broadband connectivity for telemedicine should be anticipated. Additional sites that

could host COWs/COLTs include University of California Cooperative Extension (UCCE) offices, Community Colleges, Public Buildings, industrial parks, etc.

The benefit of COW/COLT deployments is that the carriers currently have an inventory that can be immediately deployed. The COWs/COLTs are typically deployed at antenna heights of either 40 feet or 60 feet height above ground level (AGL), which provides wireless coverage of about 25 square miles.

The challenge of using COWs/COLTs is that current backhaul is typically managed through satellite, which can only support a handful of broadband connections, literally supporting less than five simultaneous users, particularly with streaming, so QOS management of the user connection is required. However, microwave or fiber backhaul can be utilized. This needs to be factored into deployment design.

Existing Assets

Rural California has existing assets that offer a platform to connect homes in unserved broadband areas for distance learning, home telemedicine and telework during the COVID-19 crisis. Technologies exist that can be relatively quickly deployed to close the broadband gap from those assets. Public schools and libraries are connected to the internet through the FCC USAC e-rate program. These represent a logical jumping off point to connect to unserved homes. COWs, COLTs and Aerostats are technologies that offer enhanced connectivity that can extend the reach of school / library-based broadband. Current FCC regulations and scope of waivers issued, limit expansion of broadband reach to the property of e-rate schools/libraries. An alternative is to attach Wi-Fi antennas to community buildings that already have broadband connectivity. Washington state is adopting this approach. A third approach is "drive-in" Wi-Fi where students would access e-rate Wi-Fi from the parking lots of schools and libraries and self-isolate in automobiles. This creates a double digital equity gap of being only feasible for students with drivers' licenses and access to automobiles.

Technologies

COWs, COLTs and Aerostats extend the reach of cell service to shelter in place homes without broadband. This addresses the access part of the digital equity gap. The following is a review of these options and a related successful case study.

Cells-on-Wheels and Cells-on-Light-Trucks

The commercial wireless carriers use vehicle-mounted cellular radio and switching equipment known as COWS (Cells-on-Wheels) and COLTS (Cells-on-Light-Trucks) to provide supplemental or replacement coverage. These are typically used in disaster response when existing infrastructure is damaged, but they are also used to provide supplemental coverage for sports events, large gatherings, music festivals, and to add capacity for humanitarian efforts such as

refugee encampments. As with any communications technology, COWS/COLTS require electrical power, and connectivity to the network aka "backhaul". In rural deployments without electric power and fiber optic backhaul, COWS/COLTS may serve voice and SMS messaging only and are powered by petroleum-fueled generators. If electrical power and fiber optic backhaul are available, COWS/COLTS can service voice, SMS, and broadband data typically using 4G LTE technologies.

Figure 1 COW next to Paradise Town Hall

The COWS have the capacity to expand the coverage and capacity of cellular networks. The range can be up to several miles depending on obstructions and vegetation. To provide residential service, mobile phones at home would need to be used as hotspots to connect other home devices. The mobile phones can be used directly in some cases; not much to do homework though, perhaps for video or voice call, or web browsing. Connecting too many residential devices (i.e., tablets, laptops or PCs) to the COW enabled network might stress capacity. However, if the mobile carrier has plenty of cellular bands (licensed spectrum), then it can provide more capacity. Removing data caps can also help residential customers to use the service for distance education and telemedicine. Video applications for downloading or streaming a lecture could easily reach a data cap of GBs. Same with extended video conference sessions for telemedicine. COWs need to be connected to a backbone which can be satellite, microwave or fiber on the ground. This backbone capacity will also determine the aggregated capacity that the COW can provide to connect mobile or home devices. For first responders, it s definitely a good solution which can be deployed quickly. The California Interactive Broadband Map can be used to identify existing coverage of ISPs and mobile carriers and more importantly to identify potential gaps in coverage that COWs can fill. David Espinoza, Broadband Specialist, Geographical Information Center, California State University, Chico, On the Potential of COWs.

Aerostats

These are unmanned lighter-than-air vehicles, tethered to the ground, carrying cellular equipment. Power is provided via heavy-gauge conductors in parallel with the tether. They're typically raised to heights of 1,000 – 2,000 feet above ground, which allows a wide coverage footprint. Backhaul can be either (a) fiber optic cabling in parallel with the tether, or (b) high-bandwidth wireless point-to-point

links. In the case of wireless point-to-point links, the ground site for the wireless link must have fiber optic service.

The Aerostat can be deployed within eight hours, provided a standing FAA waiver can be triggered during emergencies. The site location for Aerostats is approximately half a football field or half a baseball outfield. Therefore, most sporting fields, farms, large parking lots or county fair grounds are strong candidates for Aerostat locations.

Served User Equipment

Served users may use 4G-enabled smartphones, tablets, laptops, and other devices to access the provided 4G LTE signal. For users without these devices, it is necessary to convert the 4G LTE signal into a Wi-Fi signal via a hotspot – the user can then link Wi-Fi enabled devices to the hotspot. Some hotspots also allow wired networking over USB cabling. Most 4G LTE smartphones can operate as Wi-Fi hotspots.

Deployment Configurations

Using the above technologies, there are various configurations possible. For the purpose of this overview, we will ignore configurations that do not provide broadband service.

Fiber-fed COWS/COLTS

This is a well-proven configuration used innumerable times for over a decade. A COW or COLT is parked in a location near electrical power and fiber optic service. Power and fiber are connected to the COW/COLT equipment. The antenna mast is extended to a height of approximately 50 feet above ground level. Coverage from this configuration is approximately 25 square miles or a radius of 5 miles, depending upon terrain.

Fiber-fed Aerostats

The Aerostat carrier vehicle is parked in a location near electrical power and fiber optic service, with enough clearance to allow for wind-driven movement of the lifting body. Power and fiber are connected to the ground vehicle's equipment. The Aerostat is inflated with helium and the tether is extended to place the Aerostat at a height of approximately 1,500 feet above ground level. The carrier vehicle acts as the ground anchor. Coverage for this configuration is approximately 5,000 square miles or radius of 70 miles, depending upon terrain.

Wireless Linked Aerostats

The Aerostat carrier vehicle is parked in a location near electrical power. Electric power is connected to the ground vehicle's equipment. The Aerostat is inflated with helium and the tether is extended to place the Aerostat at a height of approximately 1,500 feet above ground level. The carrier vehicle acts as the ground anchor. Coverage for this configuration is a radius of 5,000 square miles.

Figure: E-Rate Site Leverage for AeroSite Broadband/IoT Re-Distribution
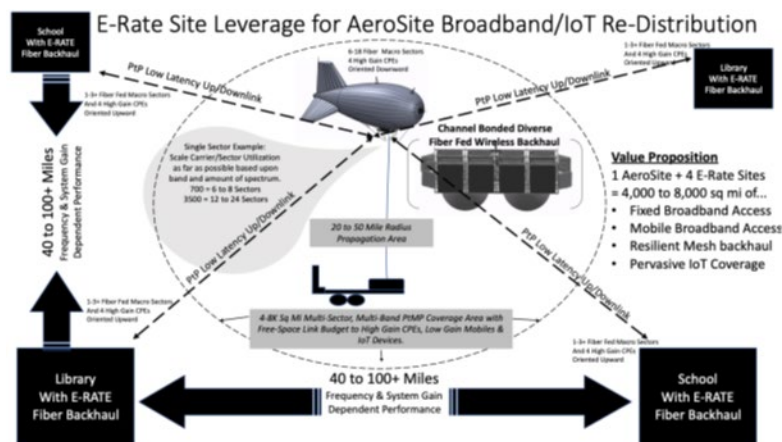
Wireless link site equipment is located near electrical power and fiber optic service. A directional antenna is attached to the link site equipment and pointed towards the Aerostat. Electrical power and fiber optics are connected to the link site equipment. The link site equipment connects the Aerostat to the fiber optic network via a managed wireless link.

Considerations for Deployments

Fiber-fed COWS/COLTS:

- Obtaining permission to park the vehicle.
- Obtaining permission to run electrical cabling and fiber optics between the COW/COLT and the service building.
- Physical security of the COW/COLT.
- Cybersecurity
- Contracting, insurance, etc.
- Limited coverage area.

Fiber-fed Aerostats

- Obtaining permission to park the ground vehicle.
- Securing a location with enough clearance to allow for wind-driven movement of the lifting body and tether.
- Obtaining FAA permission for use of airspace, issuing safety notices to aviation.
- Obtaining permission to run electrical cabling and fiber optics between the ground vehicle and the service building.
- Physical security of the ground vehicle.
- Cybersecurity
- Contracting, insurance, etc.

Wireless Linked Aerostats

- Same as Fiber-fed Aerostats, plus:
- Obtaining permission to locate the wireless site link equipment.
- Engineering the link to ensure signal performance – managing distance losses, foliage obstructions, etc.

- Obtaining permission to run electrical cabling and fiber optics between the wireless site link equipment and the service building.
- Physical security of the wireless link site equipment.
- Cybersecurity
- Contracting, insurance, etc.
- Statutory change by Congress is required to allow FCC waiver of e-rate restrictions from e-rate schools and libraries from connecting to homes.

Advantages of COWs, COLTs, and Aerostats (CCAs)

	COWs	COLTs	Aerostats
Offers **immediate deployment** potential	X	X	X
State experience deploying for firefighting disasters	X	X	In Process
Off the shelf technology	X	X	X
Relatively inexpensive compared to broadband fiber installation	X	X	X
Can be quickly deployed to areas of need and redeployed	X	X	X
Mobile / Portable	X	X	X
Can be connected to existing backbones	X	X	X
Operating Height of Radios/Antennas (feet above ground level)	40' - 60'	40' - 60'	1,000' – 2,000'
Coverage Area (square miles)	~25	~25	~5000
Coverage Radius (miles)	~5	~5	~70
Time Required to Deploy	2 hours	2 hours	8 hours

Case Study: UC ANR Kearney REC Wireless Project

UC ANR began exploring a project to cover the 330-acre Kearney Research and Extension Center (REC) with Wi-Fi across the property in May 2017 with Bluetown[1], a Danish company that puts together outdoor, low-cost, off-the-shelf, professionally configured Wi-Fi coverage solutions that are either grid or solar powered. The project was completed in early 2018.
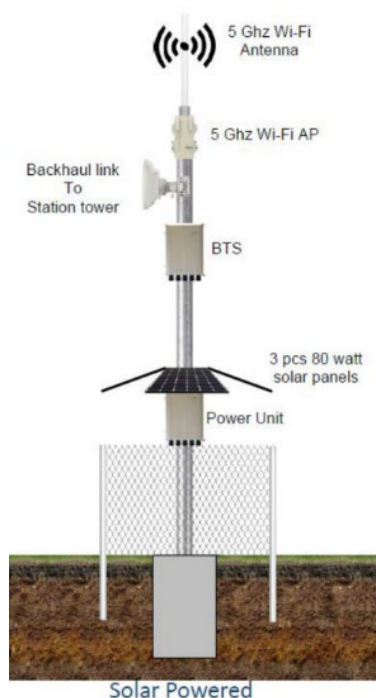

Bluetown, a group of former Nokia executives, has deployed these solutions across large parts of Africa and India, and has an excellent track record. They proposed a solution to cover all 330 acres with Wi-Fi, using a combination of grid-powered and solar-powered towers that all point back to a central unit on top of the main building at Kearney, which connects to the fiber backhaul in the building, providing well over 100 Mbps across the Center and across every field. The total solution cost $38,000, with some other in-kind prep and engineering work done by Kearney. This solution gave Wi-Fi across the property using the fiber internet as the main source of connectivity – much like a home wireless router is connected to a cable or DSL wired connection. The radius for the Wi-Fi is about a mile per tower, depending on obstructions like trees and hills. In a subsequent project Senet LoraWAN gateway was added which allowed connecting low-bandwidth sensors across the property. This "snapped in" to the Wi-Fi network, but added a much longer distance connection for sensors, roughly a 9-mile radius of coverage, but for very low speed connectivity of things like soil moisture sensors, irrigation flow meters, and weather towers. That project cost an additional $6,500. This solution works very well for Kearney REC – greatly enhancing research and innovation work onsite.

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[1] https://bluetown.com/

Difference Between UC ANR's Wi-Fi Network and a COW or COLT

5 Ghz Wi-Fi Antenna

5 Ghz Wi-Fi AP

Backhaul link To Station tower

BTS

3 pcs 80 watt solar panels

Power Unit

Solar Powered

ANR's solution is Wi-Fi, so it needs an existing internet connection to work (e.g. the Wi-Fi on your phone or computer), whereas COWs and COLTs are all cellular mobile services that connect to and enable the mobile services of phones (e.g. 3G, 4G, 5G) that work through your cell provider (AT&T, Verizon, T-Mobile, etc.).

Those solutions are different, but based on the needs in each community, could be put together so that Wi-Fi is the community-based solution, or Wi-Fi is the "backhaul" to connect a COW/COLT/Aerostat to provide mobile service. There are lots of options based on an individual community's needs and they are specific to how the solution will be used.

Longer Term Response

Longer-term issues of distance learning to the home has both infrastructure and regulatory implications. FCC's e-rate programs have provided broadband to most school districts[2] (98%) enabling access at the school to distance learning classes and distribution of school assignments via the internet. But this has led to the school to home (*work*) gap. Part of this is regulatory since the FCC does not allow connection from the schools to the homes for broadband coverage. Perhaps, with enabling statutory changes, as an emergency response, this policy could be suspended to enable home distance learning.

Broadband infrastructure investment and construction need to be ramped up in order to meet the demand from distance learning and telemedicine. Telework should also be added as a demand driver. An important consideration for new broadband networks is to ensure that enough capacity is built into the network. Sharp demand increases from distance learning, telemedicine, and telework could slow down responsiveness.[3]

If we are to prepare for future health safety pandemics and other catastrophic events, we will need a war time type crash program to build a resilient robust high capacity broadband infrastructure that connects all Californians.

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[2] https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2019-broadband-deployment-report, p 31
[3] https://www.nytimes.com/2020/03/16/technology/coronavirus-working-from-home-internet.html

Funding and Channels for CCAs deployments:

Note, potential resources and requirements are in flux. Applicability of programs depend upon specifics of the project.

Federal COVID-19 Economic Response[4]

- FCC:
    - Request telecommunication providers to accommodate customer needs
    - Regulatory Waivers
        - E-Rate Gift rule,
        - Schools and Libraries outside venue access
    - Congressional Waiver Needed.
        - Statutory language needed to allow e-rate funded schools and libraries broadband to be extended to (unserved) homes and for use as backhaul connection
    - CARES Telehealth Funding: $200 Million for broadband connectivity and devices
- DHS: FEMA (Existing Disaster Response Structure)
- USDA: Rural Development
    - Community Facility Program (Has funded a COW)
    - CARES Additional Funding for Broadband Programs related to COVID-19
        - ReConnect: $100 million
        - Distance Learning Telemedicine (DLT) Program: $25 Million
- EDA: CARES $1.5 Billion Grants
- Treasury: https://home.treasury.gov/cares
- US D Ed: $30.75 billion under CARES hardware, software, and connectivity are eligible expenses
- IMLS: Institute of Museum and Library Services: $50 million for immediate support to communities for digital inclusion and capacity building.

California - State Coronavirus Emergency Response for Distance Learning Broadband Communications

- California Department of Technology – Leads team
    - California Broadband Council
    - CETF
    - CPUC
    - Broadband Consortiums
    - California Department of Education – link to public schools

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[4] Information is continuously changing.

- Office of Emergency Services (OES)

- Private Sector / NGO / Universities
    - Telecommunications Providers following lead of FCC and CPUC
    - Technology Companies
        - Google https://9to5google.com/2020/04/01/google-california-student-wifi/
            - Donates 4000 Chromebooks
            - 100,000 Wi-Fi access points for rural households
            - 3 months free internet
    - Joint Venture Silicon Valley
    - Chico State Geographical Information Center (GIC)
    - University of California Agriculture and Natural Resources (UC ANR)
    - Corporation for Education Network Initiatives in California (CENIC)