HIGH SPEED RADIO CONNECTIONS:
TIMELY, LOW COST, LONG DISTANCE LINKS

"The radio link between UCR main campus and Citrus Art Facility has not only saved the College more than $132,000 over the 10 years lease term, but also provides a secured, reliable and high bandwidth communication network for faculty and graduate students to perform research activities comparing with the only vendor AT&T in that area who can only offer T1 with maximum 6 MB upload and download bandwidth. This innovative solution has enabled the facility to fulfill the research requirements and the goal of saving cost. "

-- James Lin -- CIO, UCR College of Humanities, Arts and Social Sciences

"CHASS leased an off campus facility at 1111 Citrus Street, about three miles from main campus, for our MFA Art Studios. While the new studios work for our students, we were challenged with a network issue that needed to be robust to support our students and faculty. We were informed by the property management company that the only opportunity for network solutions would come from the local cable company. The down side would be very low speed and significant cost. Reliability would be another potential problem. I discussed the challenge with the staff at UCR Communications. They listened to our needs, offered great solutions, provided us the understanding of return on investment and designed a solution beyond our expectations.

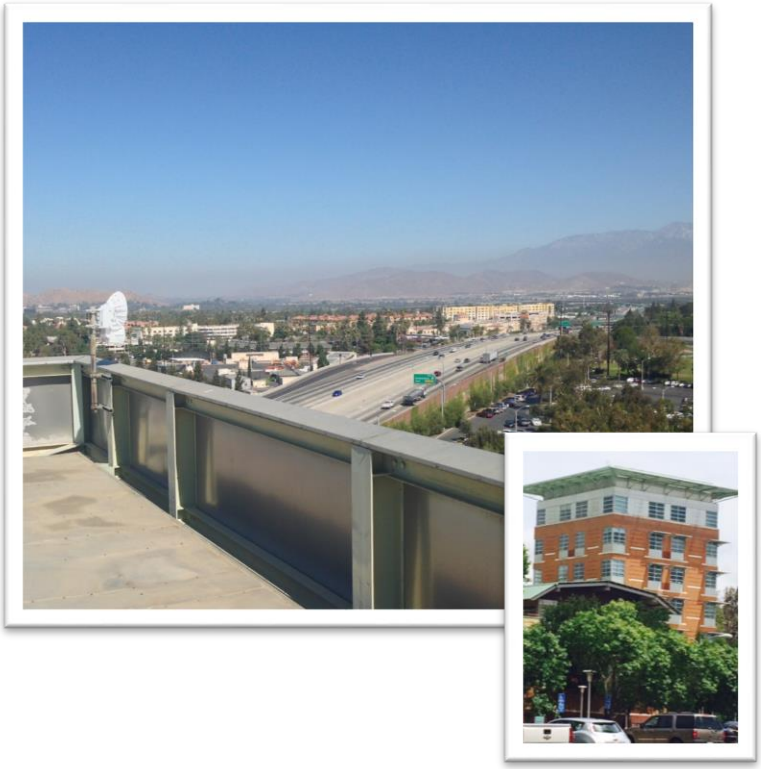
The team assembled a cost estimate, drawings, and scope of work to both CHASS and the property management company. They worked alongside the property management company providing the necessary information and access needs. The installation was timely and on budget. The equipment and connections were clean-fitting and attractive.

The connection speed and reliability have been beyond our hopes. This teamwork within the unit certainly shows the professionalism, expertise and more importantly a desire to accomplish the academic mission and vision of the University. Their enthusiasm to make this project happen was exceptional and I feel this accomplishment should be something the campus should be proud of. My sincere appreciation to the entire team. -Paul R. Richardson Director of Facilities College of Humanities, Arts and Social Sciences "

-- Paul R. Richardson -- Director of Facilities College of Humanities, Arts and Social Sciences

Background

UC Riverside began to utilize outdoor radio communication technology many years ago in order to meet the networking needs of departments located off campus. These sites are physically located beyond the reach of the campus communications' infrastructure, and fiscally beyond the budget required for recurring costs for vendor services for high speed connections, and the onetime costs to extend campus fiber and copper infrastructure to the sites.



The UCR team began to test its abilities with outdoor radios over twenty years ago with the first implementation to a new Kiosk located at UCR's south entrance to the campus. Unable to afford the installation costs for campus point to point fiber, the team installed one dish at College Building North with direct "line of site" to the Kiosk building located across the freeway and over 1000 feet away. This first implementation provided only 1Mbps of throughput, but it was a very sufficient and affordable network connection for the one or two staff manning this information building. The electronics for this connection have been replaced over the years, and we are now providing 56Mbps bandwidth to this site. The location of the originating dish was moved to the top of a newer, taller and more strategic building. The seven story tower of the Humanities and Social Sciences Building (HMNSS) now serves as an essential microwave hop providing affordable high speed network connectivity to several other off-site campus operation units.

One of the next implementations of high speed radio communication technology came a few years later, and it has also utilized the strategic location of the HMNSS seven story tower to provide a network connection of 56Mbps to UCR's Agricultural Operations and Research site located adjacent to the campus. The 480 acres of the Agricultural Operations site is just south of main campus and consists of several buildings, greenhouses, two field stations, multiple gated entrances, and a staff of 40 or more researchers. This site is now served by Air Fiber radios providing over 1Gbps of throughput to this world-renowned research facility.

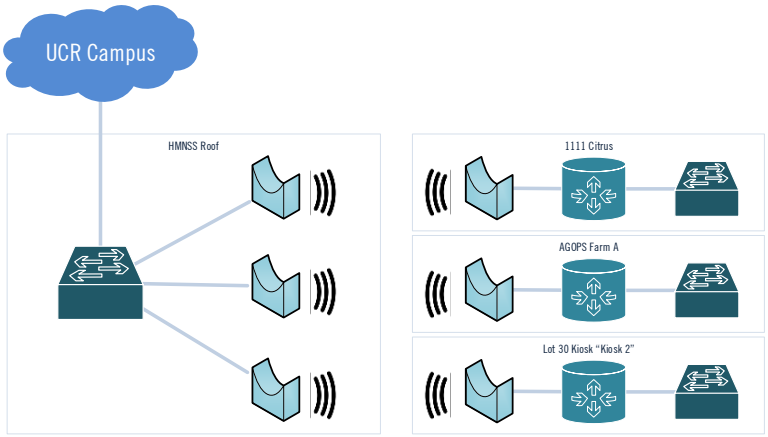


Figure x: Humanities and Social Sciences Building Roof Networks

The knowledge, experience, and confidence acquired in these early implementations led the team to propose and quickly implement this technology for the UC Center project, a very important project for the University of California.

INNOVATIVE

From the beginning, UCR had proposed the installation of a dark fiber 10Gbps connection for the UCPATH Center site, with a reliable and diverse redundant link. The team evaluated three different options for the redundant link: A vendor-provided Metro Ethernet solution; a diverse City Fiber with a microwave hop; and, the third option, a microwave solution with two hops from Box Springs Mountain. The team's highest priority was to find the best redundant solution for maximizing bandwidth and availability at the lowest cost. The non-negotiable objective was to provide 10Gbps over UCR managed fiber leased from the City of Riverside's utilities with a reliable high-speed, low-cost backup link.

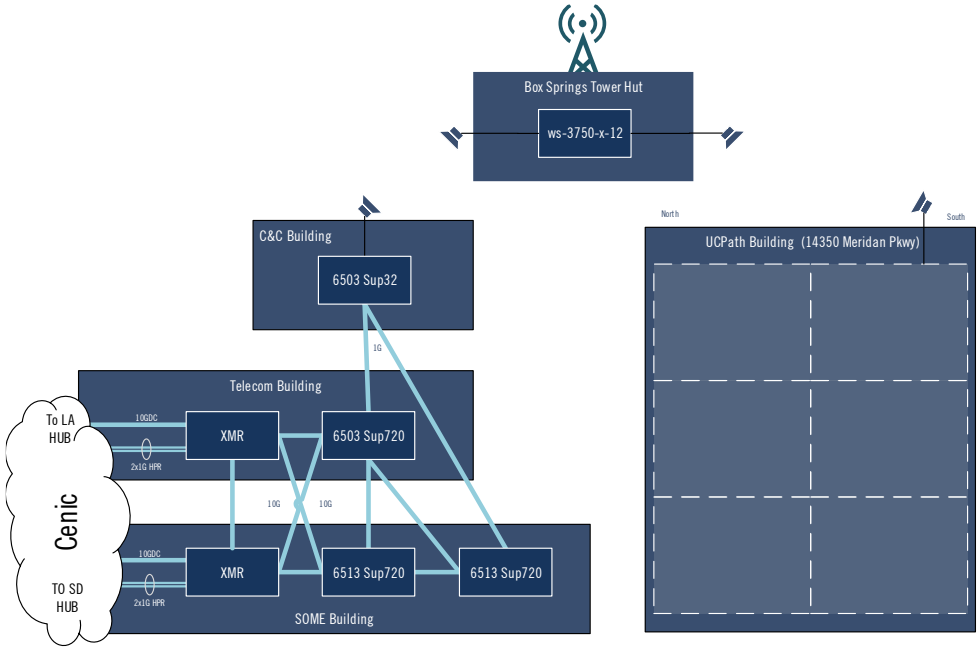


Figure: Intellicenter / UCPath Connectivity to UCR

This same team was not only asked to provide temporary voice, network and wireless services on the first floor, but they were simultaneously tasked to design the permanent network for the third floor, to provide a10Gbps fiber link, and to provide a fully functioning link by Spring 2013. In addition the team also provided the planning and provisioning of communications infrastructure for inside and outside, and delivered voice and data services to the Center.

By moving quickly to install the high-speed microwave back-up link ahead of schedule, the UCR Network team overcame both a move-in date that changed several times—the project moved more rapidly than initially planned—and the delay of the installation of the primary fiber link. The link they installed provided the initial network connectivity to the UCPATH Center site, and it avoided delays in the opening of the UCPATH Center. This link remains an affordable, diverse, and essential backup link for the UCPATH Center. The estimated costs of the various backup solutions considered are provided in the table below.

Backup Link	Bandwidth	Installation Costs	Recurring Cost
Carrier MetroEthernet	10Gbps	$5,000	$10,000
Diverse City Fiber with 1 Microwave Hops	1Gbps	$110,000	$500
Box Spring 2 Microwave Hops and UCR Labor	1Gbps	$10,000	$0

"The microwave link from UCPC to the UCR campus has proven to be a stable, reliable high-performance backup link for the UC Path Center offices in Riverside. Joint testing by UCOP and UCR Network shows that the failover is seamless and effective. I commend the UCR Network team for the low-cost and useful design, solid installation and their ongoing maintenance and management of the link."

--Erik Frietag-- Network Manager, UCOP

PERSISTANT AND COLLABORATIVE

The team demonstrated extraordinary innovation, persistence, and coordination for the UCPATH Microwave Project. The initial "line of sight" surveys for the microwave solution from Box Springs to UCPATH did not appear promising and were complicated because they required two microwave hops. The team continued to consider the other two options for a backup link (Metro Ethernet and diverse City Fiber), as the Box Springs microwave link was regarded as a last resort. In the end, the other options were eliminated and the team worked together to plan, coordinate, purchase, and construct cables, connectors, pulley systems, power cables, power sources, microwave frames, and testers. They engineered and configured the network and physically installed the network electronics. The UCR team members climbed the 60' tower on Box Springs Mountain, installed cables and crafted microwave stands on the roof of the UCPATH Center building, C&C building, and the Box Springs Tower. They worked together to troubleshoot intermittent bandwidth, power, and sustainability issues. On May 21st, 2013, the team was successful in cutting over the UCPATH Center network from the vendor provided temporary 3Mbps circuit to the UCR C&C-provided microwave service at over 1Gbps.

OPERATIONALLY EFFICIENT AND SHAREABLE

The Box Springs microwave link project was a huge success for UCR and a huge benefit to the UC system, particularly the UCPATH Center. It continues to provide a blueprint for ongoing "hard to reach" University sites with requirements for high speed connections. While the dark fiber project was completed on time and very close to budget projections; the "backup" radio link was operational prior to the primary link, and it was completed significantly under its projected budget.

The UCR network team now commonly considers and utilizes this technology as a standard network provision for hard to reach off campus locations. Below are some other sites for which the network link has been upgraded or provided via radios. All of these sites have realized the same benefits of higher bandwidth and low start-up costs and long term cost savings.

Project Name	Bandwidth Before	Bandwidth After
UCR Information Kiosk	no connection	56Mbps
Schneider House Watkins Avenue	11Mbps	56Mbps
Agricultural Operations	1xDS1 1.544 Mbps	>1Gbps
UC Path Center	2xDS1 1.544 Mbps	>1Gbps
UCR Printing Atlanta Avenue	2xDS1 1.544 Mbps	>1Gbps
Agricultural Operation (6) Gate Project	No Connection	150Mbps
University Advancement 1955 Chicago	No Connection	>1Gbps
UCR Arts 111 Citrus Avenue	1.544Mbps	>1Gbps
UCR Baseball Canyon Crest Avenue	1.544Mbps	>1Gbps
UC National Reserve System Boyd Deep Canyon Reserve	1.544Mbps	>1Gbps

Finally, it should be mentioned that the most recent implementation was installed at the Boyd Deep Canyon Reserve, and we are particularly proud of this one. It is one of the total 39 sites in the University of California Natural Reserve System and the planned site for a UCNRS new conference center building which will be visited by researchers from all over the world. On November 10th, 2015, the UCR team completed a network upgrade to Boyd Deep Canyon Reserve site. The speed tests to this site show over 500Mbps each way. We are extremely pleased with the success of the network upgrade to this reserve site, and look forward to working with UCNRS staff to identify other reserve sites that will be able to benefit from UCR's approach to long distance radio communications.

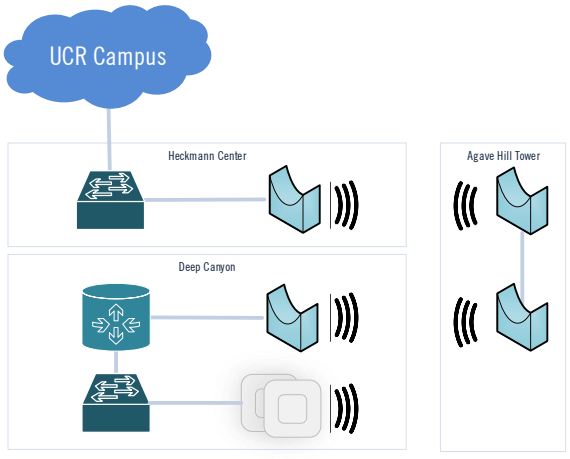


Figure: Heckmann to Boyd Deep Canyon Network

UCR will continue to utilize microwave solutions for long distance high speed network links for the benefit of the University of California for years to come.

Testimonials

"I watched the progress of the UCR Microwave implementation and am very impressed with the out-of-the box thinking the team engaged in to create this incredibly low cost and comparatively high-bandwidth solution. Traditionally we have used vendor's leased lines for backup links and these have a substantial ongoing monthly cost. UCR has already used this technology to upgrade the speed of other off-campus locations while simultaneously reducing cost. This is a great solution for last-mile connectivity"

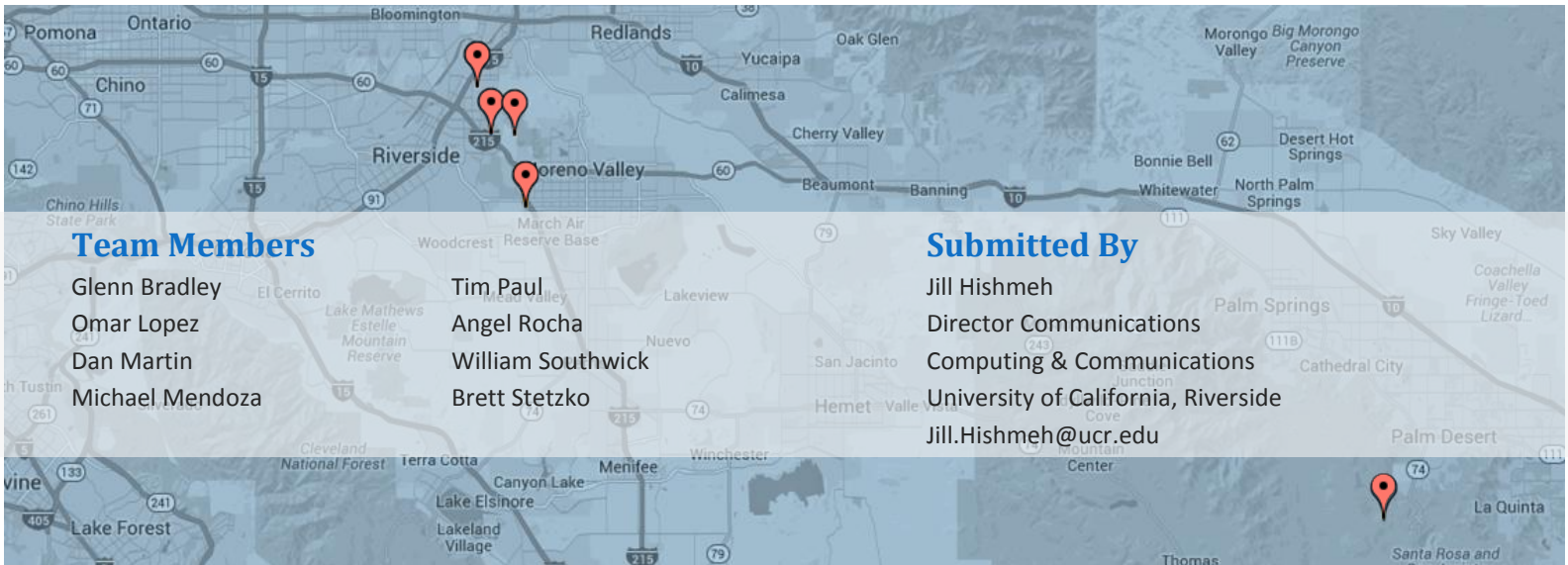
--- Bob Grant -- Executive Director and CTO, UCR Computing and Communications

"For years we used a rather expensive T-1 line to send and receive files and run email systems at the plant. At first this worked pretty well. Initially files were five to six gigabytes in size which worked fine with the T-1 line, but as designers increased the complexities of their designs, the file sizes grew to 200 gigabytes and more. As you can imagine, sending these large files using our old method became unmanageable, so we looked into the possibility of hooking up our off-site operation using fiber optics. It quickly became clear that we could never afford this since the City told us just to start the connection they would need more than $50,000. Since we are a self-support department this wasn't in the cards, so we asked your operation for help and you came up with a very creative microwave solution. Admittedly I don't even begin to understand what you went through or the technical aspects of how it works, all I can tell you is that we now can send files back and forth to the campus at speeds unimaginable before this solution was put into place.

The best part of this story is that not only can we transfer files much faster, we are also paying less than we did for the old T-1 lines per month! How often does that happen where you get more for less!

Thanks so much to you and your staff for your creativity and willingness to help us succeed!"

--- Dallas Johnson -- Service Enterprise Director, Atlanta Printing Facility



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