In the process of replacing a 30-year-old analog radio system, Douglas County officials in southern Oregon embarked on a 15-year journey to update aging equipment, improve countywide coverage, offer increased coverage for neighboring counties and state agencies, and meet the FCC’s narrowbanding operation deadline of Jan. 1, 2013.

Landmarks on this journey included delivery of a complex interoperability study, opposition from both inside and outside the county, development of 13 bid specifications, and a five-year design-and-construction process for a large county that extends from sea level at the Pacific Ocean to the 9,182-foot Mount Thielsen 110 miles away in the Cascade Mountains. Creative solutions to tough engineering challenges have delivered more effective radio communications for this 5,000-square-mile county of rugged hills and valleys, nearly 2.8 million acres of commercial forestlands, and the Umpqua River watershed.

**Project Background**

In 1991, a technology-consulting group performed an initial study of the county’s existing radio system, with recommendations on how to extend its life until it could be updated. During the following 10 years, equipment failures were documented to illustrate the need for a new radio system to county decision makers. Given increased interoperability challenges and the FCC’s narrowbanding mandate, a second study kicked off in 2001 with the goal of implementing a new system. This most recent effort used Sparling, with offices in Seattle and Portland, Ore., as the lead consulting engineering firm, along with Salem, Ore.-based Monart Associates and Wireless Network Services.

A geographic information system (GIS) analysis revealed that the existing system, comprising four hilltop sites spread throughout the mountainous county, provided effective coverage for only 75 percent of all roads in the county. Users on the remaining 25 percent of the roads experienced significant gaps in coverage or rough reception, particularly in heavily forested areas.

Based on the region’s unique opportunities and challenges, a 14-site, six-channel VHF conventional...
A simulcast radio system was selected for public-safety agency use. A simulcast type of system is appealing to a rural area with rugged terrain and a large geographic area. It incorporates a “voting” system for the receivers and a simulcast system for the hilltop transmitters. The voting system automatically selects the appropriate hilltop for best reception to maximize inbound voice quality from a mobile or portable and to simplify system operation. The simulcast system simultaneously transmits the signal from all of the hilltops, which reduces the number of radio channels needed for a large system and simplifies system operation for users. As a result, first responders don’t need to switch channels on their radios to receive excellent coverage, regardless of where they are in the footprint of the system.

This system was selected for three fundamental reasons:

- Excellent coverage is provided given the region’s rugged terrain and vegetation. The new system improves overall county road coverage from 75 percent to 92 percent. In addition, individual fire and police departments can talk with one another for incidents that involve multiple agencies, rather than relaying messages through dispatchers.
- The county can reuse existing mobile and portable radios that are

Problem No. 1: Spectrum
Details: No additional channel capacity within the county
Solution: Move a group of users with the least amount of interaction with the main users to another frequency

Problem No. 2: Site Locations
Details: Lack of funding for a needed new site
Solution: Partner with a utility to share the site, spectrum, and costs

Lessons Learned
Following are lessons learned from the Douglas County, Ore., project that could be applied to similar projects:

- If your radio upgrade or replacement project is at the bottom of your jurisdiction’s priority list, take incremental steps to move it higher on the list. Document all outages and try to include these instances on public-meeting agendas. In addition, seek and recruit other agencies that might benefit from a new radio system. For example, Douglas County’s new microwave system will provide data connectivity for county offices in two cities, which permits the county to stop leasing T1s at a cost of $450 per month.
- Make an effort to obtain and maintain the support of all stakeholders, from personnel in charge of project funding to users of the newly installed radio systems. This effort requires constant, careful communications to keep all stakeholders apprised of the developments, challenges, and rewards of the project. Complications that arise on large projects are often caused by people problems, not system problems. Thus, staying in constant touch with stakeholders will help move the project forward.
- If possible, dedicate one or more representatives who are familiar with the “lay of the land” — jurisdictional processes, departmental responsibilities, internal and external politics — to work with consultants, be available to answer questions, and provide guidance to the project.
- Resist pressure to put the system online before it is ready to be launched. This is important for several reasons. Advancing a project of this magnitude too quickly can result in hard-to-solve technical issues. Under the pressure of an aggressive schedule, resulting technical problems can cause unhappy users and diminished support for the project. As previously mentioned, an extended project schedule also allows more time to collect funding, possibly from unexpected sources.
- Resist the temptation to provide new features unless they address a specific user need. Most public-safety users just want to grab the microphone and talk. One of the challenges when designing and configuring a sophisticated radio system is to keep it simple from a user’s perspective. There is plenty of opportunity to activate added features after the system is in use and is successfully achieving its main objectives.
- Building a case with decision makers and politicians early and often is extremely helpful, as they can diplomatically move a project forward with local permitting officials, landowners, or other outside agencies.
- Look for innovative ways to recoup project expenditures or share operations costs by marketing the radio system to other groups; for example, school districts, local utilities, and other jurisdictions.
- Take great care in choosing technology consultants. It’s critical that a level of trust is established with this group early in the project, as you may be working with them for several years. Maximize the resources that consultants and other groups bring to the table, as they may have the skills and knowledge to develop innovative funding opportunities for projects.

— Ray Duncan and Brian Nordlund
Problem No. 3: Political Opposition

Details: Perception by citizens and staff that public-safety officials would be forced to use inappropriate technology

Solution: Continually and comprehensively educate and inform decision makers

currently in the field. Installing a different frequency or technology would have incurred a cost ranging from $340,000 to $960,000, depending on the frequency and technology.

Dedicated channels are provided for interoperability with adjacent counties and state agencies. As the majority of the neighboring counties use a VHF system, public-safety officials from outlying areas can use their radios while working in Douglas County and vice versa. The two counties that use a different technology and/or frequency band will maintain a second radio in their vehicles to permit interoperability with the new Douglas County system.

While a simulcast VHF system was the preferred choice to improve interoperability, at the time the study was completed there was no additional capacity in the VHF band to add channel capacity. To meet the requirement of increasing the number of VHF channels for public-safety use, a fundamental piece of the overall system recommendation was to move the county’s public-works department — roads and county engineering — from VHF to another frequency band. The public-works department was identified as having the least interaction with other agencies. Moving these 200 users to another frequency band freed space on the VHF band, which improved the capabilities and channel capacity for fire, police, search and rescue, and emergency medical responders.

Following a comprehensive cost comparison of several trunked and conventional options, a 15-site UHF trunked radio system was recommended to serve the county’s public-works department. The increased number of channels available on the UHF spectrum permits users to communicate on different frequencies via talk groups that share a set number of channels. In addition to Douglas County’s public-works department, Douglas County’s jail and health departments also use this system for daily communications.

As with most new radio system projects, tower site location was key to controlling site-development costs. On this project, all but two of the new system’s sites were built at existing tower sites, each with serviceable roads. To help absorb the cost of building one of the new radio sites from scratch, Douglas County partnered with a local electrical utility, Douglas Electric Cooperative, which serves the area surrounding one of the new sites. In exchange for constructing power to the radio site, the co-op was given access to the UHF radio system for its internal communications. The FCC granted a waiver that allows Douglas Electric Cooperative to use the public-safety frequencies licensed by Douglas County under FCC Order DA-6-1996, where improved safety for utility personnel and potential interoperability between the utility and the county were cited as justification for the waiver.

This partnership was instrumental in circumventing the problem of not having commercial power at a site, while controlling project costs.

Pushback

The trunked UHF radio system is a great solution for noncritical communications and departments; however, at this time, various limitations make it less desirable as a primary first-responder system than the simple-to-use conventional VHF system. For example, similar to a cellular system, calls are slightly delayed through the system, which could impede law-enforcement officers during a critical operation such as a high-speed chase. The trunked technology that was recommended and installed, MPT 1327, is widely used internationally. As an open standard, it’s compatible with products from many vendors, which helps keep costs to the county at a minimum.

Although the trunked system was never intended to serve first-responder agencies, concerned citizens and county staff expressed opposition because of a false perception that the trunked system would serve as the primary system for emergency responders. While the trunked system could be used to supplement the simulcast system on the VHF band, it was never intended to be the only system for emergency communications.

A critical element to the team’s ability to field opposition and move the project forward was to establish the groundwork years before the project started. To avoid rushing the system design and construction process because of political reasons, Douglas County officials continually educated and informed commissioners about the project goals beginning in 1991. During the 15-year history of this project, at least six current and past commissioners were instrumental.

Despite opposition at many turns,


### Project Problems

#### Problem No. 4: Funding

**Details:** Limited funds for a complex system

**Solution:** Procure separate bids for each element of the project; take the time to get as much grant funding as possible

the decision to take time in planning, selecting, and implementing the system was fruitful, as it gave adequate time to secure $1.2 million in grant funding for the project. With an additional $400,000 raised by the Winston Fire Department through aid from the Federal Emergency Management Agency (FEMA), the total project cost for the county was reduced to $7.6 million.

#### Bid Specifications

Radio systems are often procured through design-build contracts, whereby one contractor designs, specifies, builds, installs, and commissions a system. However, on a complex project, a design-build contractor will often mark up the cost for the vast majority of system components. To better control costs, Douglas County chose to procure separate bids for different elements of the project. While this meant that more than a dozen bid specifications were produced, it resulted in better pricing on items such as the simulcast system, site construction, microwave radios, towers, and generators.

#### Design and Construction

In upgrading the 30-year-old radio system, site real-estate acquisition and permitting proved to be a significant factor in the length of the project. While addressing problems with the leases for the proposed changes to existing radio sites, the county also had to acquire 10 new radio communications sites. An additional complication was that many of the sites were located on Forest Service or Bureau of Land Management (BLM) lands and required agency approval of site designs before leases could be drawn up or construction work begun.

Following the study and development phase, the upgrade project took more than five years from design to completion, resulting in a complex system encompassing the following:

- An 18-site digital microwave system, including five new towers and two sites built on raw land;
- A 14-site paging system for the county’s 30 to 35 fire agencies;
- A more reliable VHF system with excellent coverage to support approximately 400 radios used by public-safety agencies;
  - A new UHF system that supports 300 units for public services; and
  - An upgraded dispatch center with new consoles, CAD, and records management software.

Ray Duncan is director of the Douglas County radio project, captain (retired) with the Douglas County Sheriff’s Office, and city councilman for the city of Roseburg, Ore. Brian Nordlund is an associate in the technology consulting practice of Sparling, an engineering and technology-consulting firm. Contact Duncan at rgduncan@co.douglas.or.us and Nordlund at bndlund@spalring.com.

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# Radios Coverage

**Audio**

Manual audio delay allows simulcast phasing adjustments in 1.0 microsecond steps. Delay can be installed at transmit sites and remotely controlled by dtmf tones or centralized at the main site. It can be ordered with line equalization if all link types are not the same.

- Convex Manual Delay
- Harris Automatic Delay
- Convex Audio Distribution

**Frequency**

Carrier frequency must be ultra-accurate, so simulcast transmitters are typically locked to GPS Master Oscillators with 10 MHz (or 5 MHz) outputs, which keeps transmitter frequency within 0.1 Hz of other sites. CTCSS (= PL = CG) outputs locked to GPS assure synchronization between sites.

- Spectracom Master Oscillators

**Voting**

- Analog audio from multiple receive sites is brought to a voter comparator. The signals are continuously compared, and the best quality signal is sent to the dispatcher and repeated out over the air. Voter supports 2175 Hz / 1950 Hz / or E&M unsquelch indication.

- A voter monitoring system can be connected if the comparator is located at a remote transmit site.

## On-line Case Studies and Application Notes

- SimulcastSolutions.com
- 585.223.4927 tel

- In Phase & On Frequency

- 18 Port Meadow Trail
  Fairport, NY 14450