By Rick Burke

Consider Channel Repacking to Increase Capacity

Radio spectrum is a limited commodity, and viable, cost-effective methods to enhance spectrum use that maintain reliability and performance are paramount. For two-way radio systems, narrowbanding and new 700 MHz spectrum are the most prevalent solutions being considered to increase radio system capacity. These solutions require significant capital investments and long-range implementation planning. Given economic conditions, these solutions aren't achievable for many public-safety agencies across the country. Channel repacking, however, requires no major capital investment, yet can achieve significant capacity improvements.

Channel repacking is a design solution that results in increased channel capacity. In a typical repacking scenario, existing LMR infrastructure is retuned and radios reprogrammed to optimal frequencies that allow additional channels within the same geography, yet maintain the same interference protection. The process is similar to rebanding. The key difference is that the systems and radios occupy the same band, so no equipment needs to be replaced. All radios are reprogrammed and all stations retuned. In the repacking design, co-channel and adjacent channels would be short spaced to distances allowing reduced co-channel base station separation. Reducing the spacing of co-channel base stations facilitates the allocation of additional radio channels at specific radio sites where required.

Commercial cellular operators routinely repack their systems, referred to as system retunes. Cellular systems are retuned with the push of a button, without the need for combiner retuning, and the subscriber devices follow the system to the new frequencies. As we have learned through 800 MHz rebanding, LMR systems aren't so adaptable, requiring manual intervention on the base and subscriber ends and wreaking havoc on regional interoperability plans. The retunes affect all licensees in a repacked area regardless of whether every licensee needs more capacity. To go through such efforts, the benefits must be significant and cost recovery for existing licensees must be addressed.

Licensing Guidelines

To understand the potential benefits of repacking at VHF, UHF, 800 MHz and other congested bands, it's important to understand FCC Part 90 regulations that guide LMR network engineering and channel licensing. Long ago, the FCC adopted standard co-channel base station separation criteria and radio coverage contour prediction methodologies. The FCC rules state the allowable adjacent and co-channel interference contours are 40 and 22 dBu, respectively. This contour coverage prediction methodology is a simplified radio coverage computation model where transmitter power, antenna height and height above the average terrain (HAAT) are computed to determine an RF coverage distance along one of eight basic radials from the base station. Terrain is computed at regular intervals along the cardinal azimuths of 0, 45, 90, 135, 180, 225, 270 and 315 from 1.9 to 9.9 miles from the site along these radials to eventually compute predicted RF coverage based on a lookup table.

LMR radio sites have the right to interference protection. Co-channel interference protection requires a minimum separation distance of 70 miles between co-channel sites. However, co-channel base stations can be reduced to 55-mile separation — 107 mile co-channel base station spacing must be respected in California and Washington state — in certain circumstances, a procedure known as short spacing. These regulations were designed when calculations were performed by hand and ray-tracing propagation models with high-resolution terrain weren't available. The contours are only rough approximations of coverage and can result in gross over or under prediction of the interference picture.

The process of allocating licenses can also result in inefficient spectrum use. Except for the initial distribution of radio frequencies, new frequencies are distributed on a first-come, first-served basis. A new licensee will request the best frequency for a system, usually the one with the greatest co-channel and adjacent-channel geographic separation. Over time, these systems create more inefficiencies, and systems could have highly variable co-channel separations.

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These technical and process inefficiencies combine to reduce frequency reuse in the LMR bands and contribute to far less capacity available to licensees. Repacking doesn't require interference to increase among licensees; it optimizes the frequency reuse to maximize the number of times each channel can be used while minimizing interference. In fact, in some areas, contours may underpredict interference and put public safety at risk. If co-channel separation can be engineered below the 55-mile short-spacing rule and maintain low interference levels, more radio channels can be allocated and deliver high-quality radio communications at the same time.

Repacking and Engineering

The program begins with a channel capacity study and end-user requirements analysis to determine channel requirements. The assessment must determine where channels are needed. A thorough inventory of licensed radio spectrum, base stations and infrastructure, radios, controllers and other assets, together with channel use throughout the area, must be gathered and assessed. Because neighboring system operators will be impacted, they must approve the plan and be compensated if changes are required in their networks. Ideally, repacking costs would be shared by multiple operators in a region because additional radio channels are likely needed by many operators in a region, all of which will benefit from the program.

A detailed radio propagation and interference analysis must be conducted over a wide geographic area to assess and eventually engineer a radio channel allocation architecture that will achieve desired channel capacity, RF coverage and radio channel interference protection, and ensure the highest reliability of LMR network performance. In facilitating the detailed RF engineering study, radio engineers can incorporate directional, down tilted, reduced height and alternative antenna design, base station and mobile radio power reduction, new base stations and other methods to design an LMR network that satisfies FCC and neighboring requirements.

As mandated in FCC rules Title 47, Part 90.699, a detailed engineering study for channel repacking must show that incumbent LMR operations are protected from interference and that operator compensation has been addressed. A neighboring operator has a right to comparable facilities, mandating that the repacking design be reliable, achievable and provides a greater return on the investment than alternative solutions to increase channel capacity.

Operational Complexities

In a cellular network that employs planned frequency reuse, hybrid combiners are often used, allowing transceivers to be retuned at will. The retune is programmed centrally and pushed out to the affected cell sites in a region. When the retune occurs, the cell phones in that area automatically re-scan the spectrum to find the new control channels, and the cellular system directs users to the new voice channels and handoff neighbors.

The process is far more laborious in LMR systems because of a variety of factors. First, many systems across the country use conventional mode where the frequencies are hard coded in the base station and radio. Next, to reduce the number of antennas on towers, multiple channels are combined to a single cable and antenna. The combiners used in LMR systems must be manually retuned to operate on the new channels. Finally, the portable and mobile radios must be re-programmed to access the new channels. Retuning radios is the most time consuming and highest risk aspect of rebanding or repacking channels. Over-the-air radio programming and the ability to store multiple trunked radio system frequency plans in Project 25 (P25) architecture will help address these issues for the future.

LMR systems are designed with dominant sites that serve beyond jurisdictional boundaries. This is done to enable “roaming” beyond the border, but also allows for a single dominant site that can provide disaster recovery coverage. Mobile power levels may exceed what’s needed to sustain good voice quality. This “excess power” could cause interference at a neighboring system. While these practices reduce complexity or improve system reliability, they can reduce the frequency reuse of the band. A holistic review of system design could be a critical component in the most efficient yet reliable repacking solution.

Optimal channel repacking can double capacity without impacting system performance for cellular systems. The same or better increases are possible with LMR systems depending on the process of channel assignments and the use of contours or radius as the channel separation mechanism. Substantial capacity increases are then feasible while maintaining low intersystem interference levels. The results and benefits will vary by market and will benefit certain geographic environments more than others because of terrain and morphology and incumbent radio network layout and architecture. Ideally, public-safety entities would migrate to more spectrally efficient technologies such as P25 Phase 1 or Phase 2. This may not always be feasible or even sufficient to satisfy the demand. A number of operational complexities exist to implement a repacking program; given the current economic crisis, repacking could be the best plan B. ■

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