DECISIONS, DECISIONS

The system engineer faces myriad choices before a radio technology can be selected

June 1, 2010 12:00 PM, By Ira Wiesenfeld, P.E, and Robert C. Shapiro, P.E

Reprinted by permission of Urgent Communications.
http://urgentcomm.com/networks_and_systems/mag/lmr-procurement-201006/index.html

In earlier installments of this series, we explained why a thorough understanding of user needs is a critical early step for any systems engineer charged with the task of designing and implementing a land mobile radio system. The next critical step is to understand the procurement process, which includes interfacing with consultants and conducting technology assessments.

LMR systems have budget cycles that are unique when compared with those of other industries. The cycles and life expectancy are stretched to extremes due to the difficult nature of obtaining funds. Most budget cycles for public-safety LMR systems extend 15 to 20 years or more. In contrast, most IT capital projects are amortized over 10 to 15 years, and other similar projects have cycles of 10 years or less.

Grants and bonds are the typical funding sources for public-safety LMR projects. Grants are allocations provided by all levels of government, with the federal government providing the majority. Grants, which don't have to be repaid, often unencumbered. However, some impose certain stipulations, e.g., limiting the time allocated to build out the system and/or stipulating the technology that will be used. For example, most federal grants today for public-safety LMR systems are tied to the APCO Project 25 technology for reasons of interoperability and to maximize efficient use of the spectrum. In contrast, bonds are issued at all levels of government and essentially are low-interest loans provided by the public. As such, bonds are the same as debt and must be repaid from other income, such as taxes.

After the initial budget is established, a consultant typically is hired. The type and size of consultant depends on the size of the user community and its needs, the budget and the hiring agency's technical expertise. Both large and small LMR consultancies exist, ranging from companies with as many as 100 consultants to individuals. The consultant first will prepare user-needs and technology assessments, and then establish budgets for ongoing consulting services and for a vendor to build, deploy and manage a network. To screen and select a vendor, the consultant will draft a request for information (RFI) and perhaps a request for proposal (RFP). The consultants then will review the responses and assist with the deployment and management of the network as needed.

After understanding the user's unique procurement and budget processes, the next step is to conduct the technology assessment, which involves numerous key elements that are based on user needs, available technologies and budget. Whether the system will reuse existing frequencies is one of the first assessments that must be made. If the new system will be using new frequencies, or will operate on a different band than the client currently uses, then it simply can be constructed, tested and then turned over to the client. But if existing channels must be reused, then the old system needs to stay operational and a plan to orderly convert all units from the old system to the new system must be part of the system design.

Next, depending on the number of subscribers and the number of radio frequency channels that are available, a decision must be made concerning whether to trunk the channels. Typical subscriber loading is 70 per conventional channel — this is an FCC requirement for 700/800/900 MHz systems — and 100 per trunked channel, not including the control channel. Generally, a conventional system will cost substantially less than a trunking system. However, when multiple departments or groups have to share the system or when there are more than 150 subscriber units on the system, then a trunking system will provide a better grade of service for the users. Generally, the more users that you have, the more advantageous the use of the trunking system becomes.

Another important assessment concerns whether to use analog or digital technologies, or a combination. The main advantage of analog systems is that they are simpler to design, cost less money — largely because they utilize less-expensive radios — and do not require any special brand of radio to be compatible with the system.

However, with the narrowbanding mandates in the lower frequency bands now — the FCC requires that most Part 90 systems operating between 148-173 MHz and 400-512 MHz must utilize 12.5 KHz or equivalent bandwidth by Jan. 1, 20103 — and similar mandates in the higher bands and for tighter bandwidths will be coming in the future.

Digital systems are rich with features that might make the additional cost of such systems, compared with analog systems, well worth the investment. Also, digital systems usually offer a migration path that enables them to easily be upgraded as further enhancements become available. And they offer operational superiority that simply is unobtainable from an analog system.

The main factor to consider when trying to choose between analog and digital is that once a manufacturer is chosen for a digital system, the system will be dependent upon that manufacturer for the life of that system. This is because most manufacturers do not license access to software and system features to rival manufacturers. It is this lack of compatibility between manufactures that prompted the Associated Public-

Safety Communications Officials (APCO) to start its APCO 25 project that evolved into the Telecommunications Industry Association's Project 25 standard, the first phase of which requires digital radio manufacturers to utilize a common air interface so that systems are not locked into any one manufacturer's devices. But the promise of P25 in terms of interoperable communications will not be realized fully for years to come.

Given the richness of digital systems, it is vital that the system engineer fully understands the user's needs and requirements to ensure that the cost of the new system falls within the budget criteria of the system owner. If everyone had unlimited capital and operating budgets, system design would be easy. Since that is not the case in almost every instance, the job of the system designer is to balance all of the critical factors and make the difficult choices in order to develop the best system possible given the funding that is available.

Many of the new systems on the market today use an Internet Protocol (IP) digital stream to link all parts of the system, particularly radios and consoles. In the newest systems, base stations communicate via IP with mobile and portable units. As time moves forward, more systems will use this approach.

Many public-safety agencies cover an operational area that exceeds the capability of a single-site system. In addition, topographical and geographical conditions often have a limiting effect on system range. Consequently, steps must be taken to overcome these limitations. There are several tactics that a system designer can use for this purpose, including:

- Multisite channel-changing by the end user
- Multisite trunking
- Multicast on multiple sites
- Simulcast
- Receiver voting

The simplest and least-expensive way to overcome a wide geographic area is to let the mobile and portable end users choose the operating channel that is optimal based on where the field unit is relative to the tower sites. In some circumstances, that is not a good plan. For instance, a police chase may lead officers into areas with which they are unfamiliar; consequently, they likely won't know which channel is best as the chase progresses through the territory. The solution to this dilemma involves the dispatcher determining the channel to which the field unit will move as the signal starts to break up. But most field personnel do not like this method, so the system designer only uses it when money and other factors are so limiting that no other options are available.

Multisite trunking systems — which scan the system's available channels and then automatically direct the user to the best-available option — and multicast systems — which transmit identical signals from multiple sites to mobiles and portables in the field, which then automatically select the channel with the best reception — are better alternatives. Both work very well when channels are available. But when channels are not available, then the system designer will need to consider a simulcast system, which extends the coverage area by using multiple transmitters to broadcast the signal at the exact same time on the exact same frequency.

Because the base system transmits using a very large amount of power — up to 500 W effective radiated power — while the mobiles and portables have a much smaller amount of transmitter power, a common way to extend the range of the system is to place receivers throughout the operational area and bring the receiver signal from multiple sites back to a single site. A "voter" system then determines the best audio signal and retransmits it. There are quite a few voter systems available in the marketplace, and these will be discussed in detail in a later article in this series.

As the engineering of a land mobile radio system begins, funding comes into play, budget and equipment life cycles become important, and the procurement process must be fully understood. Then, technology and topology start to factor the equation. It is vital that the system designer become aware of all of the technology that is available. Each manufacturer will be more than happy to tell the system designer that its technology is superior to that of its competitors. Each manufacturer also will be more than happy to design the complete system for you. Beware of this approach, as it will lock you into a system that may not exactly meet the needs of the end users. Finally, as the system requirements start to take a more definitive shape, technology becomes even more important in terms of fulfilling the system owner's requirements.

Future articles will examine the selection of the primary radio technology and how that technology integrates with the rest of the system. Just as Rome was not built in a day, system engineers require many months or years of experience and training to be able to cover all of the details required to put such systems together.

Part 1: Class is in session: Basic LMR and FCC definitions
Part 2: Start at the beginning: Understanding LMR user needs
Part 3: The devil's in the details: Conducting a user-needs survey

Ira Wiesenfeld, P.E., is a consulting engineer who has been involved in the radio communications business since 1966. He is a senior member of the IEEE and has been a licensed amateur radio operator since 1963. He can be reached at ***iwiesenfel@aol.com****.*

Robert C. Shapiro, P.E, is the senior manager-systems engineering for ***PlantCML****. He serves on the TIA TR8 committee as the TSB-88.4-C task-*

group chair and is a senior member of the IEEE. He can be reached at ***bob.shapiro@eads.com****.*