START AT THE BEGINNING

Understanding user needs is the crucial first step to effective system design and engineering

Apr 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/understanding-lmr-user-needs-201004/index.html

As professional land-mobile radio, or LMR, systems engineers begin the design process, the first and most important element to understand is the user's needs, whether it is a public-safety agency — police, fire or EMS — public utility, public-transit agency or large enterprise. All will have unique needs — and challenges.

The relationship between the systems engineer and the user community is critical. The systems engineer may support the users directly, or instead may support the integrator, vendor, supplier, consultant or design organization. This relationship grows over time and as trust is built between buyers and sellers, integrators and users, a foundation for good communications is established that is critical when planning, implementing and testing LMR systems.

The first step in the process of assessing user needs is the user-needs survey, which is divided into operational sections and levels of management, and which covers budgeting, radio coverage requirements, fleet mapping, capacity planning, governance and equipment engineering.

Once the user-needs survey is done, the budget becomes the next item to be considered when planning an LMR system. This is important as it sets the level of expectation of the buyer and seller and allows the systems engineer to understand the most important aspect of the user needs.

In light of the budget discussions between the buyer and seller, the distinction between CapEx, or capital expenditures and OpEx, or operating expenses, is relevant. The CapEx money required to build the LMR system may come from tax revenues, bonds or grants, and is typically limited to the acquisition and buildout of the system. This CapEx budget does not include ongoing costs such as site rent, system maintenance and management. These costs fall under OpEx and are managed differently than CapEx. The systems engineer must be aware of the impact of the design on OpEx costs. Too many radio sites, for example, could increase rent costs to the point where OpEx rises above the scope of the budget.

The next important aspect for the systems engineer is to understand the radio-coverage requirements. The coverage requirements establish the bounded service area and this correlates to the budget.

The bounded service area is the area defined by the user that describes the operational requirements. This area could be a metropolitan area, city, multi-city, county, multi-county or state. It is important that facts about the area — such as terrain variations, clutter and morphology features, population density, location of key facilities and services, and availability of communications sites — are well-communicated at this stage.

When discussing the coverage requirements and the user's bounded area, it is important to note the reliability and confidence levels. For most LMR systems, reliability is defined by references such as TIA TR8 TSB-88 and is in the range of 95% for location and area calculations. For location reliability, or quality of service, a radio-frequency coverage study usually is conducted at a certain design level, and a factor is assigned to ensure that at any given point there is a level of confidence that the signal is as predicted. The reliability factor is stated as a fade margin and defines the amount that the signal may fade from being stable to unstable. The area reliability is based on the bounded areas and represents a comparison of points above the design level and below the design level. This representation is defined by a percentage, e.g., the aforementioned 95%, and relates to the critical needs of the user. The quality and area reliability are normally stated as percentage of time and location, such as 95% of the time and 95% of the location.

When assessing user needs, a review of the available spectrum is required and the FCC's rules and regulations must be visited for the particular user classification. The results of this discovery will help the system determine how to meet coverage requirements and the operational needs of the user — or whether they can be met.

Technical references such as the TIA TR8 TSB88 series provide LMR system engineers with planning and measurement techniques that allow for the best possible design for the system users. TSB-88 begins with a definition of service area, then discusses the channel-performance criteria, or CPC, which is a method of determining quality of service using digital audio quality, or DAQ as a reference.

TSB-88 then looks at various methods of measuring quality of service, such as bit error rate and BER versus DAQ. It also considers propagation modeling and simulation reliability, both of which benefit system engineers by defining common design techniques. TSB-88 considers models such as Okumura/HATA/Davidson, Anderson 2D and the FCC Model R-6602, which relates to the height above average terrain, or HAAT, calculations.

Another important design aspect covered in TSB-88 is the study of noise and how it affects the performance of a system. There is environmental and thermal noise, both which can have a detrimental effect on signal propagation. Interference is another consideration that has many interesting aspects, including how to calculate its magnitude using the Equivalent Interferers and Monte Carlo methods.

Once the system has been defined by jurisdiction, budget, coverage requirements and user needs, the next step is to design the system using components and systems that are obtainable and have the desired features that the customer and the design engineer have agreed upon. If the design engineer is not careful, then there will be coverage, operational, maintenance and reliability issues that will plague the system forever. The equipment-engineering phase will specify each and every component in the system.

This phase provides the "big picture" of the project. The frequency band, system format, FCC licensing, site determination, equipment designation and power requirements, all are critical considerations that are part of the system design. Much thought must go into this phase, as the major part of the budget will be spent on these items and a redo or modification might be impossible due to a lack of funds. Do NOT take this phase lightly, as any subsequent changes to system design have huge implications, and the system might become unraveled from any major changes after this point. (See sidebar.)

Once the frequency band is chosen, the next step will be to determine site availability and access. Propagation modeling will allow the engineer to see how well each site will perform before the site is constructed. The amount of money spent on propagation modeling is miniscule compared to having to find a new site or having to add more sites to provide the coverage that the user desires or requires.

The planning phase of LMR systems is a very complex job. The user needs, financial budget, channel availability, site availability, coverage area, topology, system features, frequency band and component selection are just a few of the many variables that make engineering a very important part of the system design. To further complicate the job, no one vendor makes every component for a system. As a result, each component must be carefully selected to be integrated into the system design. Future articles in this series will cover some of these areas in more detail.

Part 1: Class is in session: Basic LMR and FCC definitions
Part 3: The devil's in the details: Conducting a user-needs survey
Part 4: Decisions, decisions: The procurement process

*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****.*

Frequency band selection

The frequency band selection is a critical decision. It is based upon the following:

- Frequency availability
- FCC licensing
- Other users in your jurisdiction
- Mutual Aid in the same frequency band
- Amount of geographic area that must be covered
- Number of separate sites needed