CLASS IS IN SESSION

Ten-part series will provide a primer for anyone needing to design a land mobile radio system

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Land mobile radio technologies and systems have been in existence since the Galvin Manufacturing Company and Edgar F. Johnson put the first radios in automobiles in the early 1900s. Since then, these radios have evolved from simple voice transmitters and receivers to very complex systems that require detailed and careful engineering to ensure coverage over the desired territory and modes that the customer wants and needs.

But while the spectrum allocated to LMR has expanded proportionally to the number of bands and frequencies that became available over the years, the number of users and requirements has expanded at an even greater pace. Because of the resulting shortage of free channels within a given geographical space, such systems must be designed to effectively cover the intended area without interference to themselves or other users.

So, LMR system design then requires a structured approach to allow for accurate and economic utilization of resources. Radio site selection is critical and must be handled with the utmost of importance. An incorrect location will keep the system from ever working as the end user expects and needs it to work.

In addition to site location and frequency selection, there are many factors that go into the early stages of planning for a radio system. With this in mind, *Urgent Communications* is excerpting a book being written by the authors of this article entitled *Land Mobile Radio Overview: LMR 101 and Future Considerations*. This multi-part series — and subsequent book — on LMR systems and field engineering is intended to provide LMR system designers with a reference source and set of guidelines.

This series, which is targeted to systems engineers, field engineers and radio technicians, will cover the following topics:

- Understanding LMR user needs;
- The LMR user RFP process and technology assessment;
- RF planning;
- Connectivity and backhaul;
- Dispatch, command and control;
- Interoperability;
- Radio site surveys, site selection, and field engineering;

- Radio frequency interference;
- Installation processes and standards;
- Program and project management; and
- Post-system project acceptance.

The Federal Communications Commission is the government agency that regulates telecommunications in the United States. It is organized into bureaus that represent the various distinct parts of the communications business and environment. The FCC's regulations and requirements are a major factor in how all radio systems are designed and engineered. The commission's Web site (**www.fcc.gov**) is one of the primary sites with which all radio engineers must become extremely familiar. Fortunately, it is one of the easiest Web sites to navigate and find the vital information needed to design and engineer radio systems that not only are effective, but which also are FCC-complaint.

To start, here are some basic LMR and FCC definitions:

Point-to-point: A communications path that is a singular, or peer-to-peer, system.

Point-to-multipoint: A communications path that is from one origination source to many receiving points.

Base stations: A fixed radio used to communicate to other fixed, mobile or portable radios.

Repeater: A combination receiver and transmitter that is designed to extend the range of a system.

Conventional system: A radio system that lets the user select the channel on which the system operates.

Trunked radio system: A radio system consisting of multiple channels that lets the user select the group with which the system communicates, but the system actually chooses the physical channels.

Simplex: Radio systems where the transmitting channel and the receiving channel are on the same frequency.

Duplex: Systems where the transmitting frequency is different from the receiving frequency. This is necessary for repeaters to work.

Full duplex: The ability of a station to receive on one frequency and transmit on a different frequency at the same time. All repeaters operate in the full duplex mode.

Mobiles and portables: Vehicle-mounted radios are called mobiles, while the "walkie-talkie" radios are called portables.

Fixed stations: Stations that are licensed to operate at one location.

Control stations: Fixed base stations that let the user access and talk through a repeater system.

Temporary stations: Stations that are licensed to operate for a period not to exceed 30 days.

Itinerant stations: These are stations used by companies and individuals that have a need to be in various locations for periods exceeding more than a month.

FCC parts and service groupings: The commission's rules and regulations are arranged in parts that specify the particular requirements and operating parameters for the various classifications of services regulated by the commission. These parts are very important and will be discussed in detail in subsequent articles.

Coordinators: In the 1980s, the FCC stopped coordinating radio channels for interference protection and transitioned this function to the private sector. Subsequently, industry groups and other organizations today handle the coordination function on a fee basis. Only coordinated channels can be submitted to the FCC for license applications and modifications, in most cases.

Radio bands: Radio spectrum extends from 20 kHz to well above 300 GHz. The most common bands used for LMR and microwave systems include:

- HF;
- VHF low band;
- VHF mid band;
- VHF high band;
- 220 MHz;
- UHF 380-512 MHz;
- 700 MHz;
- 800 MHz;
- 900 MHz;
- 1800-2000 MHz;
- 2.4 GHz;
- 3.6 GHz;
- 4.9 GHz;
- 5.2 GHz;
- 5.8 GHz;
- 6 GHz;
- 11 GHz; and
- 18-23 GHz.

Paging: There are individuals and groups of people who rely on small receivers that can be easily worn on their belts, stored in their pockets or purses, or somehow attached to their person, in order to notify them that they are wanted or needed immediately. There are five types of paging using two modes. The types are:

- Analog and
- Digital

The types of pagers include:

- Tone only;
- Tone and voice;
- Digital and analog voice;
- Numeric; and
- Alphanumeric.

The main thing to remember about paging systems is that they usually are part of a critical system; thus, reliability must be part of the system design. Never take shortcuts on a paging system without consulting the system owner, as the paging system usually is part of the emergency response of that organization.

Simulcast: The simultaneous broadcasting of a signal on multiple transmitters in multiple locations, but with the same audio or data on each transmitter at each site. There can be little or no difference in time or audio characteristics of any of the transmitters in a simulcast system.

Antenna gain: Antennas are designed to radiate in all directions, one direction or any combination that is needed to meet the requirements of the system designer. As such, the antenna can achieve an improvement in efficiency when its signal is redirected from non-useful directions to more useful and needed directions.

Attenuation: As a radio signal travels through a coaxial cable or through the air, the signal is reduced and this reduction is called attenuation. The nice thing, if there is one, is that attenuation can be predicted or calculated so that the system designer can factor the attenuation parameters into the system design.

With the FCC's requirement that all radio systems operating under 512 MHz — with only a few exceptions — must be converted from 25 kHz-wide channels to 12.5 kHz-wide channels (or equivalent) by Jan. 1, 2013 — with 6.25 kHz-wide channels (or equivalent) the ultimate end game — there is a need in the LMR industry to understand all of the details and implications of this change. The same holds true concerning 700 MHz broadband spectrum. Consequently, we will be highlighting these topics

from a technical and systems engineering design perspective in the articles to come.

As we continue with this series, the intent of the articles will be to increase the knowledge base of the readers so that they can apply this information to help design and maintain radio systems. As we continue presenting these articles, we welcome feedback from the readers, particularly comments and suggestions that will increase the knowledge base for everyone. Having worked in this industry for many decades, we have interfaced with many brilliant people. We look forward to hearing from such individuals, who help make this industry such a great place to work.

Part 2: Start at the beginning: Understanding LMR user needs
Part 3: The devil's in the details: Conducting a user-needs survey
Part 4: Decisions, decisions: The procurement process

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