An Innovative License-Free Alternative To FRS/GMRS

The TriSquare TSX300 900-MHz FHSS Handheld Transceiver Is Positioned To Dominate The Consumer Two-Way Radio Market

by Bernard Bates

*P*opComm's November 2007 cover story, "Digital Two-Way Radio Technology Reaches Consumer Market" covered the emerging trend of new 900-MHz FHSS (Frequency-Hopping Spread-Spectrum) radios becoming a serious license-free alternative to FRS/GMRS radios. Picking up where that article left off, this article will review one such radio, the TriSquare TSX300.

This new handheld transceiver sets a new price/performance standard, using innovative digital technologies to offer many features we're accustomed to seeing only in PCS/cellular handsets. It's about time two-way radio users and hobbyists started benefiting from these exciting new personal communications technologies.

FRS/GMRS Problems Create Opportunity

Back in 1999, TriSquare was a major OEM manufacturer of FRS/GMRS radios for several companies marketing under various well-known brand names. As the popularity of FRS/GMRS radios sky-rocketed over the next five years, the market approached saturation and profit margins dropped to unsustainably low levels. And, not surprisingly, the widespread use of 50 to 80 million FRS/GMRS radios created severe congestion on the 22 FRS/GMRS channels at crowded events, metropolitan areas, and elsewhere. Tens of millions of users, including many large

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and small businesses, blatantly violated FCC regulations by using GMRS channels without obtaining the required $75 license, or by using FRS channels for business purposes.

At the same time, many FRS/GMRS radio users became increasingly aware of the glaring feature disparity between their simple two-way radios and their feature-rich cell phones (which offered private and interference-free voice communications, text-messaging, caller ID, call waiting, contacts lists, hands-free operation, ringtones, vibrating alerts, etc.).

Engineering A Solution

In 2004 TriSquare started engineering a solution. Its years of experience designing DSP (Digital Signal Processing) and SDR (Software-Defined Radio) technologies into consumer two-way radios, and the falling cost of digital components needed to implement these technologies, convinced the company that it was feasible to build feature-rich FHSS two-way radios for the consumer market to supplant FRS/GMRS. DSP and SDR technologies allow advanced features and functions to be designed and implemented in software, and then duplicated in firmware, at far lower cost than using many dedicated electronic components.

Fortunately, the FCC had issued its Part 15.247 regulations, which authorize unlicensed 1-watt FHSS voice and limited data transmissions in the 902–928 MHz ISM (Industrial, Scientific, and Medical) band *if* certain challenging technical requirements are met.

Was a practical solution buried in these obscure FCC regulations? Since FHSS can effectively create a nearly unlimited number of "virtual" radio channels (by using many different hopping sequences)

Photo A. The TSX300 eXRS (eXtreme Radio Service) Handheld Frequency-Hopping Spread-Spectrum (FHSS) Transceiver. Never before has so much sophisticated radio communications technology with so many advanced features been available in a two-way radio priced for consumers.

it could solve the severe channel overcrowding and privacy problems vexing tens of millions of FRS/GMRS radio users. Because ISM spectrum is unlicensed, FCC licensing requirements wouldn't be an issue.

eXtreme Radio Service Is Born

Armed with its two-way radio engineering expertise and these new FCC regulations, TriSquare filed 33 U.S. patent claims and bowed out of the FRS/GMRS OEM market in 2005 to focus on what it saw as a huge market opportunity for low-cost, license-free, short-range two-way voice and text-messaging products that

TSX300
Owner's Manual

Front View Call Outs include:
1. Antenna
2. PTT Button
3. Accessory Headset Jack
4. Power On / Off Button
5. LCD Display
6. Softkey #1
7. Softkey #2
8. UP/Down Volume and Scroll Button
9. Call / Back Button
10. Lock / Next Button
11. 0-9 Alphanumeric Keypad
12. Microphone
13. Speaker

Rear View Call Outs include:
14. Belt Clip
15. Battery Compartment Door
16. Charging Contacts

Backlit LCD Call Outs:
17. Audible & Vibrate Icon
18. Test Message Icon
19. VOX Icon
20. Keypad Lock Icon
21. Battery Low Icon
22. Channel / User Interface
23. Softkey Labels

Figure 1. A page from the TriSquare user manual depicting some of the TSX300's many features and controls.

are practically immune to channel over-crowding and interference.

TriSquare trademarked the names "eXtreme Radio Service" and "eXRS" for its new technology and made plans to overtake the stagnating FRS/GMRS radio market in just two to three years with a line of portable FHSS transceivers—starting with its flagship TSX300 (**Photo A**) and its entry-level TSX100 (which has a very limited feature set but is about one-third the price). TriSquare also laid plans to establish eXRS as a *de facto* standard for licensing to other companies.

These are ambitious goals, but TriSquare is gambling that its patent-pending eXRS technology—and the many new features it makes possible—will be a big hit with a general public accustomed to cell phone features and ergonomics, and who desire a private two-way radio solution with similar features.

Complete Package

Pop'Comm asked TriSquare to send me an early production TSX300-2VP "Value Pack" for review (see **Photos B** and **C**), which is a retail peg-display package containing two TSX300 radio transceivers, two PTT/VOX headsets, two NiMH battery packs, two swivel belt clips, a dual desktop drop-in charging bay with AC adapter, and one illustrated user's manual.

After installing the two 4.8V, 750mAH NiMH battery packs and dropping the radios into the dual desktop trickle charger for the night, I noted it had built-in protection against overcharging and short-circuiting batteries. The charger takes about 12 hours to fully replenish battery packs that are fully discharged. The next morning (about 11 hours later) the radio's LCD battery gauge indicated they were fully charged.

A nice feature is the option to use three standard AA alkaline cells instead of the included NiMH pack, so in an emergency you're never at the mercy of the slow trickle charger. Additional NiMH battery packs are sold separately, in case you want to keep a spare set charging and ready for action at all times. The plastic battery cover fit loosely, but TriSquare informed me this was an early production problem that has since been fixed. Rated NiMH battery life is 15 hours based on a 5/5/90 duty cycle (5% transmit, 5% receive, 90% standby), while standard AA alkaline cells should provide about 45 hours of 5/5/90 use. My test results were consistent with those ratings.

Physical Features And User Interface

The TSX300's appearance and user interface blurs the distinctions between two-way radios and cell phone handsets (see **Figure 1**). It not only looks a lot like some cell phones, it also shares many of their features. The housing is rugged ABS/PC plastic and slightly larger than a second-generation non-flip PCS/cellular handset. Its sides curve slightly inward and are ribbed to fit comfortably in your hand, so you can operate the full keypad one-handed with your thumb.

For day/night readability the 16-button keypad has silver-painted translucent silicone keys, which are laser-etched with numerals and all letters of the alphabet. An Up/Down button and two Left/Right "Softkeys" allow selection of dynamically displayed functions and menu options—similar to how many cell phone menus work. Above the keypad is the large backlit bitmapped LCD that displays up to seven lines of text and icons, depending on the screen and function being viewed.

Other TSX300 cell phone-like features include SMS-like text messaging with message-waiting indicator, ring-

Figure 2. TriSquare TSX300 features and specifications.

tones or silent (vibrate) alert, hands-free operation, caller ID with name, call waiting with name, and voice/text privacy. (See **Figure 2** for a complete list of TSX300 features and specifications.)

The TSX300 comes from the factory with its default "My Radio" channel set to 0, but you can assign any channel from 0 to 9999999999 (that's 10 billion channels). The radio will constantly monitor that channel, regardless of what "Group Channel" you happen to be using. Group Channels, or Contacts, are used for communicating between groups of people and are not the same as the "My Radio" channel on your or others' radios, which are always used for Private Channels. It's a little confusing at first, but after reading the illustrated step-by-step manual and navigating through the fairly intuitive menus it becomes clear. To paraphrase an old advertising slogan, "This is *not* your father's two-way radio."

TriSquare suggests using your 10-digit telephone number as your unique "My Radio" 10-digit channel code because it's unique and easy to remember. But if communications security (COMSEC) is a concern, such a publicly

available number would be a poor choice. One hundred Group Channels (i.e., Contacts) can be entered and labeled with up to eight alphanumeric characters, such as George, Basecamp, Warehouse, Security, and A-Team.

Theory Of Operation

The TriSquare TSX300 is a hybrid digital/analog two-way radio designed to make the best and most economical use of both technologies. Its proprietary eXRS FHSS scheme uses 700 frequencies spaced 25 kHz apart between 906.275 and 923.750 MHz. Heavy concentrations of cordless telephone traffic around the top and bottom of the license-free 902–928 MHz ISM band led TriSquare engineers to avoid interference on those frequencies, as well as with the most commonly used portions of the 33-cm amateur radio band, which is allocated on a shared/secondary basis (many of TriSquare's engineers are hams).

Depending on which 10-digit channel code is chosen, an embedded pseudorandom number generator algorithm selects a different set of 50 frequencies to hop

and cycle through every 20 seconds. Each 400-millisecond hop frame contains both voice and data.

Since each radio "knows" (based on the channel selection) what the hopping frequencies are as well as their order, the receiving radio(s) need only know when to start hopping to remain synchronized. The receiver starts hopping when the preamble signal is received, and stops hopping 20 seconds after no signal is received. The transmitter's microphone audio is digitized, modified by a DSP algorithm to extract only the most useful information, summed with a digital timing and position signal, and time-compressed to allow proper hop framing and provisioning of the control data (caller ID, private call, etc.) within each frame. The receiver's DSP extracts the modified audio, performs digital noise reduction, and expands it back to the original voice signal timing (slightly delayed after processing).

This scheme is less DSP-intensive than full-fledged vocoders, such as VSELP (Vector Sum Excited Linear Predictive) used by Motorola's DTR series of two-way 902–928 MHz FHSS radios (see "The Motorola DTR410

Photo B. The TSX300-2VP "Value Pack" includes two TSX300 two-way radios and a complete set of accessories: two VOX/PTT headsets, two NiMH battery packs, a dual desktop drop-in charger with AC adapter, and illustrated users manual. Radios and accessories are also available individually, so you don't have to buy unwanted replacements.

Frequency-Hopping Radio," December 2007, *Pop'Comm*). As a result, the TSX300's audio reproduction sounds less synthetic and isn't severely distorted by non-speech background sounds. It's also near real-time audio, so there's no annoying delay caused by vocoder latency.

Audio Quality

TSX300 audio is quite intelligible but sounds slightly "fuzzy," like low bitrate compressed audio. Speech sounds relatively natural compared to the synthetic speech sound of some vocoders and has ample volume except in very noisy environments (where the included PTT/VOX headset can be used.) Hands-free (VOX) has three sensitivity settings and works in either speakerphone or headset mode, although the most sensitive isn't very. The included PTT/VOX headset fits comfortably around your earlobe and into your ear canal and has an inline PTT/VOX mode switch and momentary PTT button. By *de facto* design convention, the TSX300 works with many third-party audio accessories, such as XLT Communications' line of single 2.5-mm plug speaker mics, earbud mics, and throat mics designed for Motorola and Cobra FRS/GMRS radios.

Channel Overcrowding Solved?

FRS channel overcrowding and mass unlicensed use of GMRS channels has frustrated many FRS/GMRS radio users over the years, but TriSquare's eXRS technology could alleviate that. According to TriSquare, and the Kansas State University engineering study it commissioned, more than *100,000* eXRS users within talk range can enjoy uninterrupted communications in the 902–928 MHz ISM band. By comparison, several dozen FRS/GMRS users within the same talk range could render their bands unusable. Channel overcrowding, as we know it, could become a thing of the past.

Operational Range

There are many variables that determine the effective range of two-way radios, but TriSquare took the high road by refusing to make any specific distance claims—unlike so many FRS/GMRS vendors that make outlandish claims like "range up to 25 miles and more!" Instead, TriSquare guarantees its eXRS radios will "meet or exceed the range performance of other UHF HTs." Testing confirmed this claim, with range comparable to a pair of 2-watt 70-cm amateur radio Handie-Talkies in simplex mode. Outdoors over flat terrain the TSX300's effective range was about one and a half miles, and over three miles from hill to hill.

These radios performed particularly well inside tall office buildings. From the 55th floor of Philadelphia's Liberty Place tower, usable voice and text communications with another TSX300 in the lobby was achieved. Whether the 900-MHz signals bounced around inside the structure or outside and back in is unknown, but neither a pair of FRS/GMRS radios nor the aforementioned pair of 70-cm amateur HTs could accomplish this. Perhaps the TSX300's 33-cm band wavelength, which is much shorter than the lower frequencies used by those other two-way radios, passes more easily through a tall building's metal framework and window frames. Obviously, the TSX300 would be an excellent business radio in a multi-floor office building where other two-way radios can't cut it and where COMSEC is a concern.

On the road between automobiles, the TSX300's range was reduced to less than a mile, probably due to signal attenuation by vehicles' steel bodies and other obstructions.

Text Messaging

Upper-case text messages of up to 80 characters can be sent between TSX300 radios. Four custom text messages can be stored for repeat sending, plus there are six permanent "canned" text messages to choose from (YES, NO, OK, WHERE ARE YOU?, CAN YOU TALK? CAN'T TALK RIGHT NOW). A triple-beep and/or vibrate alert tells you when a text message is received, and a message-waiting envelope icon is displayed until the message is read. Text messages are sent "in the blind"; there's no error-correction or handshaking to acknowledge a message was received accurately or at all. Half-duplex synchronous data transmission makes this impossible in real time, but it would be nice if the TSX300 could *automatically* transmit an ACKnowledgement signal to the sender after receiving a text message. If the radios are within range, text-message delivery shouldn't be a problem. Oddly, the character set's punctuation is limited, offering just !?.,'@#$&().

Cloning

The settings of one TSX300 can be wirelessly cloned to another TSX300 held next to it. Selected Contacts, the full Contacts list, or the entire radio configuration can be cloned. This feature can save lots of time and aggravation for a group of users or a business needing to program several radios for interoperability. Plus, there's no cloning cable to buy or lose. Neat!

NOAA Weather Receiver

The built-in NOAA weather receiver works, but is not very sensitive. It receives strong local stations fine, but not weaker distant NOAA stations that most scanners and dedicated weather radios can pull in. The 900-MHz antenna probably has lots to do with this. Still, it's a nice extra feature in strong signal areas, but I wouldn't trust my life with it hiking or camping in the remote wilderness far from any NOAA stations.

Documentation

As with any feature-rich digital consumer electronics product, reading the manual is worthwhile. The most basic two-way radio features are intuitive enough to use right away. The 35-page owner's manual is well written and walks the user through the TSX300's many features with illustrated step-by-step instructions, but the small booklet isn't much bigger than the radio itself so its small print may be hard for some people to read. Fortunately, it can be downloaded in PDF format from TriSquare's website and enlarged as necessary. It's interesting reading if you're simply curious about the coming trend of FHSS two-way radio for the masses.

What I Liked

There's a lot to like in the TSX300 (see **Figure 2**), and its many features make it an exceptional price/performance value. It's clear that much thought went into the design of this

Photo C. The TSX300-2VP "Value Pack" in its retail packaging. It's a sign of the times when a complete and highly sophisticated FHSS voice/data radio communications system is sold on retail peg displays for less than $100. Until recently, two-way radios with similar advanced technology cost thousands of dollars and were generally available only to government and military users.

radio and its accessories. Following are some features I particularly liked:

• Exceptional communications privacy
• No interference from other users
• Advanced technology made easy
• All accessories included
• Geek/coolness appeal
• Good ergonomics
• No license required
• Non-volatile memory
• NiMH or alkaline batteries

What I Disliked

The more features any product has, the more likely there'll be some nitpicking, so here's mine:

• Ringtones cannot be assigned to specific callers, and the five ringtones are similar-sounding and unimaginative.
• NOAA weather receiver is insensitive and cannot receive weaker distant stations.
• Text-messaging character set is missing several commonly used punctuation characters like the semicolon, colon, quotation marks.

• Text-messaging message triple-beep alert is too brief and quiet, and the vibrating alert is too brief compared to cell phone handsets' vibrating alerts.
• VOX sensitivity is low; the most sensitive of three settings isn't very sensitive.

Features I'd Like To See

• NOAA SAME decoder with alarm
• Increased NiMH battery mAh capacity
• Charging/Charged indicator on drop-in charger
• Rubber overmolding for better grip and drop protection
• USB PC interface for storing different radio configurations, firmware updates, and for dispatching text messages from a connected PC (which could be automated)
• User-definable ringtones, assignable to specific callers
• Repeater capability (no restrictions under FCC Part 15.247)
• Transmitter lock (for use as a room or baby monitor)

Final Thoughts

The TSX300 is a very cool two-way radio with unprecedented privacy and other features. The more I used it, the more I liked its design and capabilities. This is an excellent first-generation implementation of consumer FHSS two-way radio technology and is an exceptional value (price/features/performance.) While the extensive digital feature set may be overkill for some users, it's a good balance between what's possible and what people will really use.

If the general public discovers it can enjoy private and interference-free two-way radio communications—with an operational range comparable to FRS/GMRS but with many more useful features, TriSquare's patented eXRS technology might just catch on and become the new preferred medium. Conveying the benefits of this advanced technology to average consumers might be challenging in the face of notorious false claims made by FRS/GMRS resellers (i.e., fantastical range claims and so-called "Privacy Codes"—which provide no privacy at all).

But TriSquare is ahead of the curve with its TSX300. Its innovative and unprecedented range of features stands apart from all other consumer two-way radio offerings. There's nothing remotely like it, except perhaps Motorola's DTR business series, which offers fewer features, less privacy, and costs several times as much.

Pricing And Warranty

Suggested retail price for the TSX300-2VP "Value Pack" is $99.99, but some online resellers are advertising it for even less. It has a one-year limited manufacturer's warranty against defects. More information can be found on TriSquare's website at www.trisquare.us.

Two-Way Radio Privacy For The Paranoid

There are lots of reasons people might want private two-way radio communications, including for personal or family matters, proprietary business operations, secret hunting and fishing spots, outdoor action/strategy games, political/social direct actions, etc. With CB/MURS/FRS/GMRS radios, all of that is easily and likely to be overheard on a handful of public channels. Worse, your kids could be subjected to unsavory messages by strangers, or even lured by criminals monitoring those channels. Granted, this is not a widely documented problem, but why risk it if you don't have to?

Until very recently, "privacy" and "consumer two-way radios" were contradictory terms. Now there's a paradigm shift that people will have to get used to. For instance, with 10 billion eXRS channels you won't be able to find and make new friends like you can by randomly overhearing people on CB/MURS/FRS/GMRS channels, or be able to scan and listen to what they're saying and doing. COMSEC can be a double-edged sword.

Arguably, TriSquare's eXRS technology might offer the general public more short-range COMSEC than landline or cellular/PCS network phone calls, which can now be remotely and instantly monitored by many people at local, state, and federal government agencies thanks to CALEA (Communications Assistance for Law Enforcement Act) and the Patriot Act. Not that most of us worry about that sort of thing, but being "off the network" can offer peace of mind to the paranoid among us.

If it's privacy you want, you may feel reassured knowing how unlikely it is that another eXRS radio user could monitor your communications without knowing your radios' 10-digit channel codes. An eXRS channel code is somewhat like a simple encryption key with 10 billion (10^9) permutations—far more than any other eXRS radio user could try manually in a lifetime. Neither scanners nor other manufacturers' two-way radios can receive eXRS' FHSS radio signals—further reducing the likelihood of interception. The characteristic of FHSS that rapidly slices and scatters a signal to appear as noise across a wide swath of radio spectrum makes it inherently difficult to track and demodulate.

Still, if you're *really* paranoid, you should know that a well-equipped and determined eavesdropper *could* use a highly specialized surveillance receiver like the WJ-8654 Microceptor to track and demodulate eXRS' FHSS radio signals. More affordable fast-sweeping receivers like those from Optoelectronics aren't quite fast enough to track and demodulate a 400-msec FHSS signal. But if you're worried about that, you probably won't be using inexpensive consumer two-way radios anyway.

It's safe to say the TriSquare TSX300 offers unprecedented two-way radio communications privacy to consumers, who can feel safe from eavesdropping by all but the most determined and well-funded spooks.