



Will Software Radio Become Real— And When?

In this fifth annual overview of software defined radio, it's reasonable to ask when—if ever—its promise will become a reality.

David B. Cotton
Contributing Editor

From the Editor's files:



SDR remains a hot topic within both the DoD and COTS community, for it

offers the promise of software reconfigurability for users, and a channel to provide signal processing technology from COTS suppliers. This month, we've divided the subject into two parts. Here in Part 1, Contributing Editor David Cotton presents the state of the industry, followed by a contributed article from one supplier with the stripes to prove success. Part 2 will run in a future issue of *COTS Journal*.

—Ed.

COTS Journal has been writing about software defined radio every January since 2000, and has published supplements on the topic in April 2002 and March 2003. But, while both interest in the subject—also known as SDR or just plain software radio—and the flow of information about it seem to grow almost exponentially, by now it seems fair to ask the question, “When—if ever—will SDR become a reality?”

Initially, the focus of software radio was almost totally on its military applications, as the United States struggled with the incompatibilities between the radio systems of its various armed forces as well as those of its allies. Next came commercial interests, as the elements of the worldwide wireless telephony industry began to see the possibility that SDR technology could help to solve some of their incompatibility problems. The startling events of

September 11, 2001, helped to highlight the fact that the public safety sector suffers from some of the same communications incompatibilities that plague the military. And today there appears to be an almost universal recognition that the entire worldwide communications structure can be strongly impacted by various elements of SDR.

But, in addition to its several enumerated markets—military, commercial and public safety—software radio also encompasses a number of technologies from antennas to base stations, chipsets, waveforms and the software to run them all. Let's take a quick look at some of the significant developments of the past year in order to see when—if ever—the promise of software radio becomes real.

Updating Military Efforts

For a number of years, the U.S. military has focused their tactical communications programs toward providing a family of software programmable radios that would both enhance their warfighters'

wireless communications capabilities and decrease the total cost of ownership of their infrastructure. This program is known as the Joint Tactical Radio System (JTRS) and an update of key events in 2003 is shown in the accompanying sidebar: “JTRS Changes Cluster Alignments” beginning on page 30.

The JTRS vision is to interoperate with allied and coalition forces. Many U.S. allies are either following the U.S. lead or, in some cases, racing on ahead. The Canadian armed forces are aided in part by the role that Canadian companies like ICS (a subsidiary of Radstone Technology) and Spectrum Signal Processing are playing in the development of key components of software radio. The Communications Research Center Canada undertook a Software Communications Architecture (SCA) Reference Implementation Project sponsored by the Software Defined Radio Forum (SDRF) and Defence Research and Development Canada. This project developed an SCA v2.1 Core

Interface Standard	Description
GSM	Global System for Mobile Communications—the digital cellular phone service for about 85 countries including Europe, Japan and Australia
GPRS	General Packet Radio Service—the data service for GSM
EDGE	Enhanced Data for GSM Evolution
IS-95 CDMA	Digital CDMA standard for U.S. cellular systems
WCDMA	Wideband CDMA or Universal Mobile Telecommunications System
Cdma2000	3rd generation (3g) wireless system
North American TDMA	North American Time Division Multiple Access

Table 1
Major Worldwide Cellular Air Interface Standards

JTRS Changes Cluster Alignments

At the heart of the Joint Tactical Radio System (JTRS) was the development of a Software Communications Architecture (SCA). Although the evolution of JTRS has been discussed every year since 2000, a thorough, comprehensive description of it appeared last March (COTS Journal, March 2003, p. 61), and is still available on the web (http://www.cotsjournalonline.com/pdfs/2003/03/jtrs_fold_out.pdf). However, since its appearance, there have been several significant new developments.

First, the previous four-cluster program was expanded to five clusters based on similar technical requirements and required fielding schedules (Table 1, Figure 1). The new Cluster 5, whose requirements were formerly contained in Cluster 2, oversees acquisition, development and production of JTRS handheld and manpack units and forms suitable for platforms requiring a Small Form Fit (SFF) radio for the 2 MHz - 2.5 GHz frequency range. The possibility of future clusters for other requirements such as Space and Homeland Security was also introduced.

Next, on November 18, 2003, an announcement was made merging Cluster 3, the Maritime and Fixed Station Joint Tactical Radio System (JTRS), and Cluster 4, the Airborne JTRS, programs. This merged program is now referred to as the Airborne, Maritime, and Fixed Station (AMF) JTRS program, with the Air Force Electronic Systems Command taking the lead for the initial phase. Although not as much is known about the merged Cluster 3 and 4 at this time, it has been included in Table 1 alongside the previous data for Clusters 3 and 4, and its schedule is shown in Figure 2.

Additionally, a decision has been made by the Department of Defense to expand the spectrum of interest of the JTRS program from 2 to 55 GHz and to extend the support of its underlying SCA to satellite communications. This means that in the future, space-based laser and RF communications may be seamlessly integrated into airborne and ground-based networks.

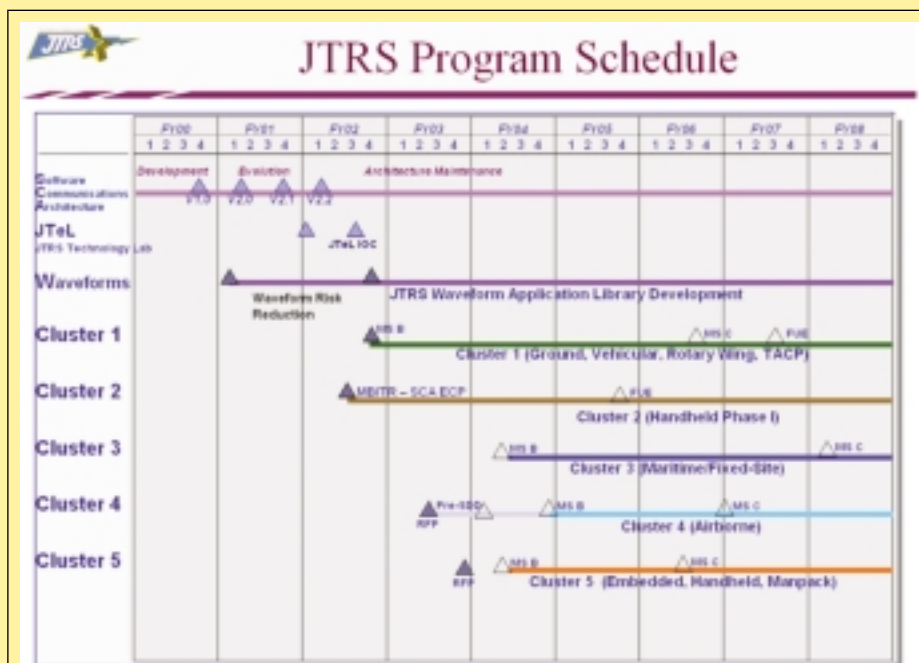


Figure 1

Schedules of the 5 clusters of the JTRS program before the November 18, 2003 announcement of the merger of Clusters 3 and 4. (Source: JTRS website.)

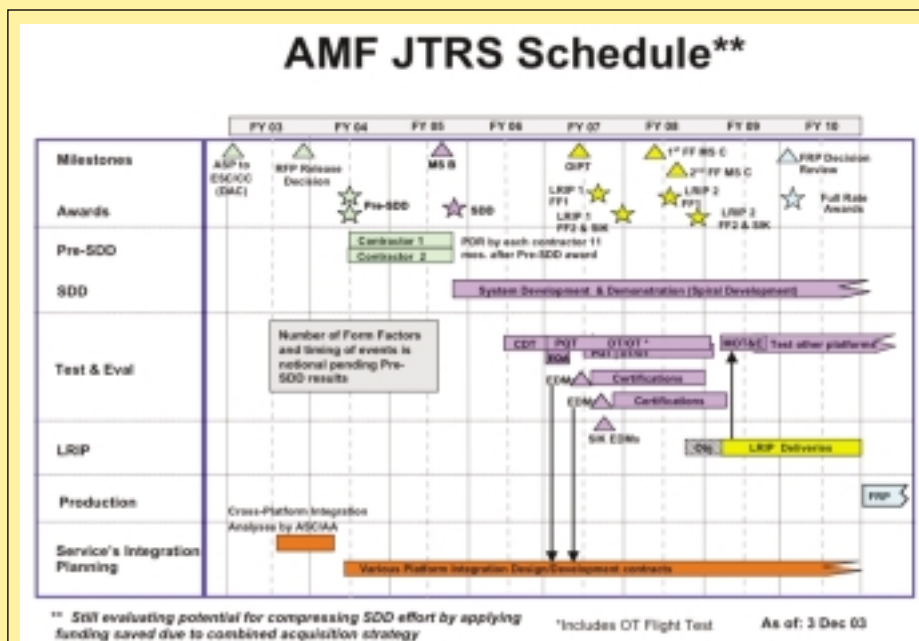


Figure 2

Schedule of the merged Clusters 3 and 4 of the JTRS after the November 18, 2003 announcement.

Cluster	Managed By	For	Radio Sets	Schedule
1	Army's Program Manager for Tactical Radio Communications (PM TRCS)	Multi-channel software programmable, hardware-configurable digital radio networking system supporting requirements from Army Aviation Rotary Wing, Air Force Tactical Control Party (TACP), and Army and USMC Ground Vehicular platforms.	Two distinct radio systems: a Ground Vehicular JTR set (with a TACP variant), and an Airborne JTR set	Early operational assessment testing: summer of 2004 Low-rate initial production beginning in 2005. First unit equipped in the second quarter of FY07.
2	Special Operations Command (SOAL-IIS-PMC4)	Handheld radios for the Army, Navy, Marine Corps and Air Force.	Evolutionary development of current Multi Band Intra Team Radio (MBITR) handheld radio to be adapted for JTRS Software Communication Architecture (SCA) compliance, incorporation of programmable COMSEC, and incorporation of the APCO-25 software waveform.	Low Rate Initial Production (LRIP): Q1 FY05 Full Rate Production (FRP): Q2 FY05
3 (Prior to Nov'03)	Space and Naval Warfare Systems Command (SPAWAR)	JTR sets for maritime platforms (sea only) for the Navy, and fixed site sets for all Services.	Block 1: adaptation of currently fielded Digital Modular Radios (DMRs) to become compliant with the JTRS Software Communications Architecture (SCA). Block 2: new acquisition to provide for narrowband and wideband requirements, including the JTRS Wideband Networking Waveform (WNW).	Block 1: Delivery of JTRS Compliant DMR sets FY 04 through FY 07 Block 2: Contract award anticipated Q1 FY04; Low Rate Initial Production (LRIP) Q4 FY07; Full Rate Production (FRP) Q2 FY08
4 (Prior to Nov'03)	Air Force Electronic Systems Center, Global Grid Product Area Directorate (ESC/DIGR)	A family of JTRS radios cost-effectively meeting users' needs, incorporating features to enable network-centric capability, understanding that networking capability is the foundation for defining radio requirements. Radio system design must be responsive to each individual platform and its respective constraints.	Acquire, test, and field airborne joint tactical radio sets for all services under following program tenets: <ul style="list-style-type: none"> • Warfighter focused: provide needed operational capability at earliest opportunity; use evolutionary acquisition approach where practical. • Forward-looking: support migration of airborne platform capabilities; maximize future capabilities to support network-centric warfare (return on JTRS investment). • Cost effective: leverage prior investment by accommodating platform constraints where possible; minimize total ownership cost (TOC). 	
Combined 3 and 4	Management and oversight structure joint between Navy and Air Force; rotates between Air Force and Navy during acquisition cycle, with AF ESC/DIGR initially taking the lead for combined program.	Airborne, Maritime, and Fixed Station (AMF) JTRS program: combines needs formerly found in Clusters 3 and 4.	Two-phase development strategy—Pre-System Development and Demonstration (Pre-SDD) and SDD. Pre-SDD is focused on system architectures and initial designs for the AMF JTRS, as well as identifying possible cost-effective hardware and software commonality across operating domains. Effort is to define system requirements and interface requirements and proceed with initial development of the AMF JTR Set through Preliminary Design Review (PDR). Pre-SDD will also include priced option for design through PDR of the Maritime/Fixed Station Service Integration Kits (SIKs). SDD will include the post-PDR development of a modular AMF JTRS design and associated form factors.	See Figure 2
5	Army's Program Manager for the Warfighter Information Network-Tactical (PM WIN-T)	Acquisition development and production of JTRS handheld and manpack units and forms suitable for embedment into platforms requiring a Small Form Fit (SFF) radio for the 2Mhz - 2.5Ghz frequency range.	Spiral 1: early delivery of handheld and manpack radios compliant with JTRS SCA & capable of running the following waveforms: <ul style="list-style-type: none"> • SINGARS ESIP • HAVEQUICK II • UHF AM/FM PSK • HF SSB w/ALE (manpack) • LMR (APCO 25) • COBRA • VHF AM/FM • UHF SATCOM DAMA (manpack) • Upgrade to MUOS (TBD) Spiral 2: handheld, manpack and small form fit radios (single and dual channel) running spiral 1 waveforms as well as the following additional waveforms: <ul style="list-style-type: none"> • Soldier Radio Waveform (SRW) • WNW • EPLRS • ATC HF Data Link • VHF for ATC • MUOS • VHF ATC Data Link (NEXCOM) • SATURN • Cellular & PCS • IBS (TBD) • VHF AM ATC <p>Small form fit sets able to store at least two waveforms. Handheld sets able to store at least six waveforms. Manpack JTR sets able to store at least 10 waveforms. All Cluster 5 sets will have GPS capability, and will be capable of automatic retransmission and routing.</p>	Spiral 1: Engineering Development Model: 3rd Quarter FY05 Low Rate Initial Production: 4th Quarter FY06 Production: 3rd Quarter FY07 Spiral 2: Engineering Development Model: 3rd Quarter FY06 Low Rate Initial Production: 4th Quarter FY07 Full Rate Production: 4th Quarter FY09
Future	TBD	Interest from Space and Homeland Security operational communities, evolving DoD requirements.		

Table 1

Joint Tactical Radio System (JTRS) Program Clusters (before and after the November 18, 2003 announcement of the merger of Clusters 3 and 4).

(Source: JTRS website.)

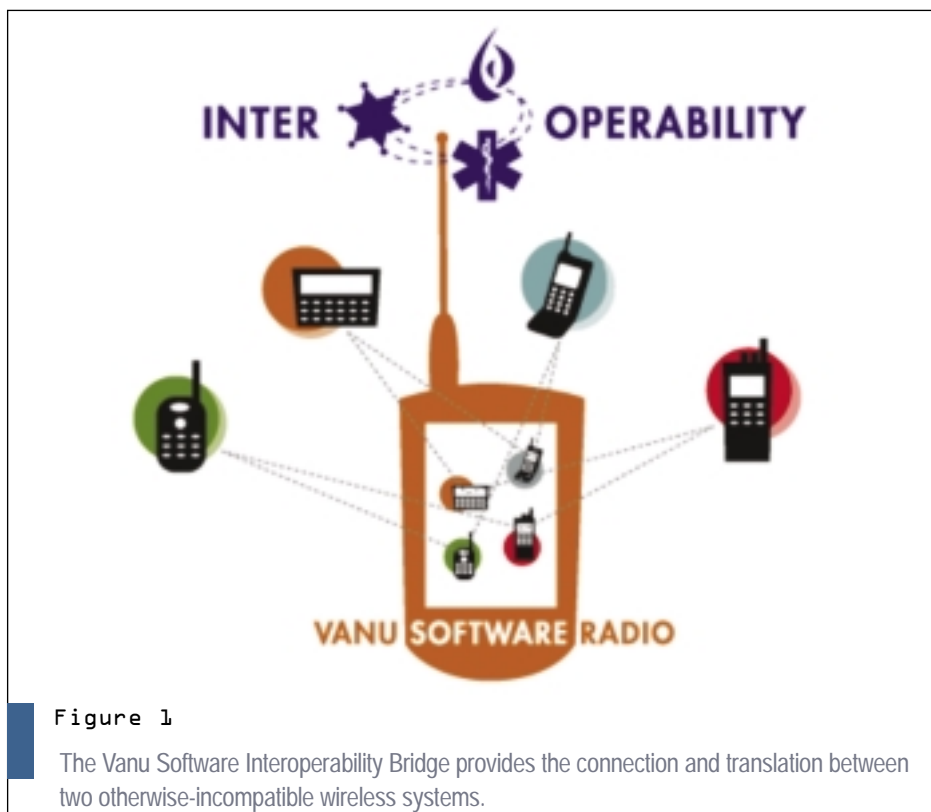


Figure 1

The Vanu Software Interoperability Bridge provides the connection and translation between two otherwise-incompatible wireless systems.

Framework Reference Implementation, written in JAVA, which is freely available online. The JTRS Joint Program Office (JPO) is converting that implementation to v2.2, written in C++.

The BOWMAN project is designed to provide a new tactical, secure voice and data communications system with greater functionality and wider interoperability capabilities for the British Army, Navy and Royal Air Force from 2005 through 2026. Its target in-service date, when a brigade headquarters and two mechanized battalions will be equipped, is March 2004. Earlier, the Personal Role Radio, a short-range non-secure section radio, was separated from BOWMAN and formally accepted into service in January 2002. Under BOWMAN, about 48,000 radios and 26,000 computer terminals will be supplied, in addition to approximately 45,000 Personal Role Radios. A U.S./UK team is pursuing an interoperability demonstration between JTRS and BOWMAN.

In Finland, Elektrobit obtained a contract for an SDR demonstrator for the Finnish Defence Forces based on Spectrum Signal Processing's *flexComm* SDR-3000 system. In Sweden, the Defence Material Administration has issued an RFP for an SCA-compatible Tactical Data Radio

System (TDRS). In France, the Multiband Multirole Radio (MMR) system demonstrated the feasibility of software radio and prepared the way for future tactical radio systems, while its follow-on, Poste Radio PRogrammable (PR2), is intended to replace legacy systems. The French work may be done in collaboration with Germany, and the French Ministry of Defense is expecting to demonstrate interoperability with JTRS radios.

In addition, the U.S. has signed a memorandum of understanding (MOU) with Japan for a cooperative R&D program of Software Defined Radios. The JTRS Joint Program Office has also engaged in discussions with representatives from a number of other allies including Australia, France, Germany, Italy, Netherlands, Republic of Korea, Singapore, Spain and Turkey. Singapore is designing a system around the *flexComm* SDR-3000, while Sweden, Korea and Japan are looking at it as well.

Commercial Update

If the activities of the SDR Forum are any indication, commercial interest in software defined radio is both widespread and growing [Editor's note: refer to the article "Software Defined Radio: Status and

Challenges", in the upcoming February issue.] Over 300 people from 15 different nations attended the two-day SDR'03 Technical Conference and Exposition in Orland, FL, in November 2003. The event featured more than 70 technical papers on topics such as signal processing, circuits and chips, and software. A day of tutorial sessions featuring topics ranging from academic engineering concepts to regulatory issues ran before SDR'03, a two-day Annual Meeting followed it and in excess of 30 exhibitors also participated.

Originally, the commercial interest in software radio seemed to spring from the desire to be able to quickly reconfigure handheld telephones for additional features or use in different parts of the world (called over-the-air software programmability, or OTA). However, for the moment cost considerations and power issues may have diluted this interest, and today the consensus is on focusing SDR on base or ground stations. This also shifts the emphasis from vendors of handhelds to operators of the telecommunications infrastructure.

In the product space, TelASIC Communications announced the BaseFlex wideband radio chipset which enables universal wireless base stations by supporting all major cellular air interface standards, including GSM, GPRS, EDGE, IS-95 CDMA, WCDMA, cdma2000 and North American TDMA (Table 1). This chipset includes a 14-bit, 240 MSPS ADC, a multi-channel programmable tuner and a 14-bit, 480 MSPS DAC. The multi-channel tuner contains eight receive and four transmit tuner paths and channelization of up to eight air interface services. Each channel can be programmed to support any individual wireless standard or simultaneous combinations of standards.

In the UK, picoChip Designs announced their PC102 massively parallel processor array for 3G base stations, claiming five to ten times the price/performance of other devices on the market. This may further contribute to the industry controversy as to which approach—general purpose processors, special purpose processors, digital signal processors (DSPs), field programmable gate arrays (FPGAs) or their various combinations—can provide the best price and flexibility for future software programmable radio systems, with

each approach having its adherents. In general, the pattern seems to be movement from DSP only or CPU + DSP, to CPU + DSP + FPGA, or CPU + FPGA only.

At the system level, ADC, Mid-Tex Cellular and Vanu announced a successful field trial of the world's first all-software GSM base station in a commercial cellular network. In this trial, ADC's Digivance Long-Range Coverage Solution (LRCS) antennas were paired with Vanu's software to provide a software radio base station serving Mid-Tex Cellular's network.

Public Safety

In the public safety sector, one of the big problems has been the incompatibility between the radio systems of neighboring communities as well as the various offices of emergency management. While the recent Homeland Security act provides some funding to solve this problem, it is a relative drop in the bucket in comparison to the need. It will probably be a long time before most public safety organizations

are equipped with basic programmable radio systems, so the recent announcement of the Vanu interoperability bridge is significant, as it may provide a short-term solution.

A prototype of this wireless device is to be developed under a contract from the U.S. Army Communications-Electronics Command Research, Development and Engineering Center (CERDEC) and it will allow several widely used radio systems to be patched together, including: VHF or UHF analog FM, Association of Public-Safety Communications Officials (APCO) Project 25 standards for public safety digital radio, and GSM and the military waveform, SINCGARS. For example, a local policeman's analog FM voice transmission can be received by the interoperability bridge, then retransmitted to federal officials on the scene of a disaster using federal frequency range Project 25 waveforms. Since the device is software-based, it can be quickly configured at the scene for the particular standards and frequencies in use (Figure 1).

Reality Check

So, how real is software radio? Is it here yet, and if not, when will it be? According to many observers, SDR is very real—if not today, certainly very soon! Hardware technologies for entirely programmable radio systems are maturing rapidly and many can be implemented now. Design methodologies for software waveform are well established. And markets are jumping enthusiastically onto the SDR bandwagon, promising a solid demand for the components needed to create a rich and stable infrastructure.

But perhaps most exciting is the development of standards—both commercial and military—for the interoperability of the flexible new radio systems. Previously, when waveforms and circuitry were separable, and different radio modes used different hardware, it was difficult—and sometimes commercially undesirable—for individual manufacturers to break out of their traditional product molds in order to achieve compatibility. But now everyone understands the

need for interoperability and the price we pay for not having it.

We are into the age of instantaneous switching from one waveform to another, where one box can look like many to the radio signal environment, and where a radio can simply listen to the environment it intends to join and adjust itself accordingly. Now interoperability becomes the defining issue and the Software Communications Architecture provides the guideposts. By having manufacturers adhere to a standard—in this case, the JTRS architecture—system users can be assured that once their new systems are deployed, the promise of compatible radios can be actually realized. We're just about there. ■■

ADC
Minneapolis, MN.
(952) 938-8080.
[www.adc.com].

APCO International
Daytona Beach, FL.
(386) 322-2500.
[www.apcointl.org].

Communications Research Center
Canada
Ottawa, ONT, Canada.
(613) 991-3313.
[www.crc.ca].

Elektrobit
Oulunsalo, Finland.
+358 40 344 2000.
[www.elektrobit.fi].

ICS
Ottawa, ONT, Canada.
(613) 749-9241.
[www.ics-ltd.com].

JTRS Joint Program Office
Arlington, VA.
(703) 588-1056
[jtrs.army.mil].

picoChip
Bath, United Kingdom.
+44 (0)1225 469744.
[www.picochip.com].

SDR Forum
Denver, CO.
(303) 628-5461.
[www.sdrforum.org].

Spectrum Signal Processing
Burnaby, BC, Canada.
(604) 421-5422.
[www.spectrumsignal.com].

TelASIC Communications
El Segundo, CA.
(310) 955-3700.
[www.telasic.com].

Vanu
Cambridge, MA.
(617) 864-1711.
[www.vanu.com].