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ABSTRACT

Public radio is about to achieve a new technological level as the new Public Radio Satellite System (PRSS) is deployed. The network will dramatically improve the capacity and quality of its interconnection system, but proper interfacing at member stations will be required to realize the full benefits of the new system. The new system uses digital transmission and includes a perceptual coding algorithm called MUSICAM, a data compression system that keeps bandwidth requirements low and audio quality high. Audio outputs will be offered in: (1) the compressed digital signal; (2) the decoded (decompressed or "linear") digital audio complying with the AES/EBU interconnection standard; or (3) standard analog linear audio. Uplink stations should note that modulators do not include MUSICAM inputs, although these may be added later. Most stations will want to use analog audio to feed live programs to their on-air consoles or for time-shifting. Details are provided about interfacing the MUSICAM output to a disk-based storage system, ancillary data interfacing, and control interfacing. The new PRSS will usher in a small revolution in the way public radio programs are distributed. One table lists additional hardware options for the new PRSS. (SLD)

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The Last Millimeter: Interfacing the New Public Radio Satellite System

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Intelligence
that you can use
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In the early 1980s, public radio stations brought American broadcasting into the space age as they became the first U.S. radio system to implement satellite program distribution. Now, public radio is about to take it to the next level as the new Public Radio Satellite System (PRSS) is deployed. For the second time in its short history, the network will dramatically improve both the capacity and quality of its interconnection system.

But to fully realize the benefits of the new system, proper interfacing at member stations will be required. This is something that will keep public radio station staffers busy for some time to come. This article will consider the major points of interface required by the new system.

Three Choices for Audio

The new satellite system uses digital transmission and includes a *perceptual coding* algorithm called *MUSICAM* (often referred to as "data compression") to keep bandwidth requirements low and audio quality high. The system's demodulators will offer audio outputs in three different formats: (1) the compressed digital signal, (2) decoded ("decompressed" or "linear") digital audio complying with the AES/EBU interconnection standard, or (3) standard analog audio.

Uplink stations should note that modulators are equipped only with analog and AES/EBU inputs, and do not include MUSICAM inputs. This may be added to PRSS modulators as an option later, probably as a field-installable upgrade.

Most stations will likely use analog audio to feed live programs to their on-air console (at least for the near term), or for time-shifting if analog tape recorders are used. AES/EBU digital audio can be used to feed DAT machines that offer AES/EBU digital inputs. (This same output can also be used to feed DAT recorders with S/PDIF "consumer" digital inputs. A front-panel switch on the demods selects between these formats.) The MUSICAM output may be useful for direct recording on future hard-disk storage/retrieval systems, or for direct feeding to another site via a telco or RF link. The use of the compressed signal allows storage or transmission bandwidth requirements to be kept to a minimum.

But the interface of the MUSICAM output to a disk-based storage system is not as straightforward as it might seem. Special hardware and—more important—software will be required from each storage-system manufacturer to properly drive its system with such an input. This is primarily due to the auxiliary (*i.e.*, non-audio) data contained throughout each program's MUSICAM datastream, a fixed 4.8 kb/s signal. (This auxiliary data is used by the new PRSS's *subscription system*, as discussed below.) At present, several leading hard-disk storage/ automation system manufacturers are reportedly developing PRSS interfaces.

Another issue likely to require some adjustment is the PRSS's exclusive operation (for public radio channels) at 48kHz sampling rate for both its MUSICAM and AES/EBU digital outputs. In some cases, 32kHz sampling is preferred by storage and transmission systems, but digital interfacing of satellite signals to those systems will require sampling-rate conversion. While this is reasonably simple for AES/EBU signals (with additional sampling-rate conversion hardware), for MUSICAM signals it will most likely require decompression and recompression (*transcoding*), because sampling-rate conversion currently cannot be performed in the compressed domain. In either case, this process may incur some minor degradation in audio quality, but the cost and encumbrance of additional hardware/steps are the greater difficulties.

On the other hand, the falling costs of hard disk storage (and the inexpensiveness of DAT), coupled with the difficulties of editing and producing in the compressed domain (which may require transcoding for every edit, for example) have caused some to advise against digital storage of MUSICAM data.

Electrically, the analog audio outputs will be at a nominal +4dBu reference level (+18dBu maximum level), with a nominal 60 ohm source impedance. Outputs will be transformerless and balanced, provided on a male DB9 connector. (A mating DB9 female plug will be provided with each demodulator.) AES/EBU and MUSICAM outputs will be at RS-422 levels and format, both provided on the same female DB15 connector. The MUSICAM will provide both data and clock outputs on this connector, while the self-clocking AES will provide only data. Note that neither analog nor digital outputs of the demods have level controls (nor do inputs on the modulators used at uplinks).

Each demodulator will also provide an input that allows access to its MUSICAM decoder section, downstream of its RF section. This permits the demod to be used for decoding of MUSICAM signals from an external source, such as previously recorded satellite signals, or signals coming from other demods or other locations. A manual switch on the front panel of the demod selects between signals from this external MUSICAM input or from the demods internal satellite RF receiver section.

However, stations who plan to distribute MUSICAM-encoded satellite signals from a single uplink to multiple stations (while keeping the signals in the compressed domain) may face some additional challenges, including the possible need for additional MUSICAM codecs and · or transcoding. The details surrounding this par ılar application go beyond the scope of this arı le, and a few pertinent issues remain undecided at this writing, so contact FISPO for more information if this applies to your situation.

Another change that the new system brings is the way stereo programs are handled. Currently, each audio channel (left and right) of a stereo program requires a separate satellite channel, so two demods are used for stereo shows, while only one is needed for mono programs. This grouping and ungrouping of demod pairs creates patching and switching confusion at stations. In the new system, each satellite channel (and each demod) is stereo-capable, and always carries a single *program*, whether it's stereo or mono. Each demod has left and right channel outputs, and in the case of mono programs, both outputs carry the same signal. This means that the six demods that FISPO will supply to stations for program audio reception can *always* carry six simultaneous programs, whether they are stereo or mono.

Also unlike the current PRSS, the new system will operate on *two* satellite transponders instead of one. The new demods are fully agile and can tune across each transponder (by frequency, not by channel number as in the current system). But their RF inputs must be physically switched between two downconverters' outputs to be able to access the two different transponders. For this purpose, *IF bus selectors* are provided as part of the FISPO package, and they precede each demod's RF input (more on these below).

Finally, a number of different MUSICAM data rates are supported by these demods, but only the two highest quality options (128 kb/s mono and the 256 kb/s discrete stereo) will be used by the regular public radio channels (officially called the *Enhanced Occasional Channels*, although this name may be changed to *Public Radio Standard Channels* in 1996). Other data rates are available for "outside" users of the system. By the way, these outside channels may come in two forms, one that is receivable on the standard demods supplied by FISPO and one that requires a different type of demod.

Note that the variable data rate capability of demods does *not* include instantaneous switching between data rates. FISPO states that it can take as much as 30 seconds for a demod to resynchronize itself when data rates change. This resync time is also required whenever there is a break in the data stream to a demod from the satellite, which will occur whenever the uplink feeding that channel is switched — even if the data rate on the channel doesn't change between the two uplinks. Best-case resync time can be as little as two seconds, however. The greater the difference between data rates when there is a rate-change, or the longer the time with no data signal during an uplink switch, the longer the resync time will typically be.

Ancillary Data Interfacing

(Warning: You are entering a heavy acronym zone [HAZ].) Along with the six audio demods, a seventh will be supplied for data reception. (Any of the demods can be used for this purpose.) This demod will be tuned to receive the *Downlink Services Channel* (DSC), which will include the new enhanced DACS messaging and data for the new *Audio Recording Automation* (ARA) system. This demod's data output will feed a FISPO-supplied PC—officially called the *Satellite Operating System Support (SOSS) Workstation*, which will use the IBM OS/2 operating system. Inside the PC is a co-processor (ARTIC—*A Real-Time Interface Coprocessor*) that connects to and controls the audio demods via an RS-485 data bus. ARTIC can also control a variety of other devices via FISPO-supplied *General Purpose Interfaces* (GPI). Among these devices are the IF bus selectors mentioned earlier and a DACS alarm panel. GPIs can also be used to control many other station-supplied devices, such as tape recorders and automation systems.

The computer also includes a modem and can be connected to a station-supplied printer. The printer can be used to produce hard copy of program schedules and DACS messages. The new DACS system will offer greatly increased speed and flexibility. (It allows ASCII and binary file attachments to DACS messages, and has an improved search engine.)

The computer's modem is used to communicate back to the PRSS master computer in Washington via a station-supplied phone line. It can be used for sending DACS messages or for downloading DACS or program scheduling data that may have been missed during normal satellite feeds. It also plays a role in the new *program subscription system*, which will allow program producers to determine which stations can receive a given program. Producers can tell the PRSS which stations are authorized to receive the program, or the producer may opt to let stations add themselves to the subscription list (via the modem), so that producers will be able to determine which stations are taking the program.

Many stations currently distribute incoming DACS messages via a local area network (LAN). In the current system, any computer that downloads the DACS messages can act as a server to the LAN for distribution of the messages. The SOSS workstation in the new system will download DACS messages in similar fashion, but it cannot be used as a server for DACS distribution because of the many other critical control functions it will perform. The best way to handle this is simply to attach the SOSS workstation to the LAN as a *client* rather than a server, and instruct it to save DACS messages to *another* PC that acts as the LAN's server.

The DACS headers and messages are saved as plain ASCII text, so they are cross-platform compatible for readng elsewhere on the LAN, using any text editor or word-processor program. But the new DACS sort-engine program is written in OS/2, so it will operate only on the SOSS workstation or on another PC attached to the LAN that is running OS/2. (Eventually, some DOS, Mac or Windows-based DACS management programs may be developed.)

Finally, the SOSS workstation will include a DACS "dribble port," a serial port that upon command will ouput DACS message headers and text in plain ASCII directly to another computer (useful in cases where no LAN exists). This data should be reasonably compatible with the current DACS sorting and viewing software.

Control Interfacing

Another component of the software supplied with the SOSS Workstation is *Audio Recording Automation* (ARA). This software controls and stores ARTIC's commands to the demods and GPIs. These GPIs can provide a flexible system of control for recorders assigned to satellite program-capture (via relay-contact outputs). The GPIs can also report the status of external devices and conditions back to the ARA system via their control-voltage *inputs*. For example, a static logic signal can be sent from a recorder to a GPI input to tell the ARA that a particular recorder is loaded and ready to record. (GPI inputs only sense the presence or absence of a given signal—they will not quantize control signals with multiple voltage levels.)

While this falls short of full serial multi-device control, the GPI inputs and outputs provide a very cost-effective method of programmable control to a large number of devices, without adding a heavy data-processing or port-hardware burden to the SOSS workstation. (Full serial machine-control interface to the ARA is a another possible future software upgrade, however.) The GPI package that comes with the FISPO equipment will include 28 GPI outputs for machine control and 28 GPI inputs for status reporting. But the system reserves 8 of these GPIs to control IF selectors and some other items, leaving 20 GPI inputs and outputs available for station use. Setup screens on the SOSS workstation are used to program how these GPIs will operate.

With some adaptation, the ARA system also could be used to provide a rudimentary form of program-stream automation, using GPIs to control devices other than those used to record satellite feeds. A helpful element for this purpose that is not yet developed is the ARA interface to an audio switching system. But "hooks" have been provided in the software to allow future development of such an interface.

Alternatively, (and perhaps preferably) the GPIs could be interfaced to another computer controlling a complete hard-disk storage and retreival system (including its own switching system), running bona-fide program automation and audio management software. Here again, some specialized interfacing software will be required, but it is likely that several radio automation manufacturers will provide such third-party enhancements to the new PRSS.

The ARA program itself operates like a database, receiving data input from the DSC. The ARA will be able to control both the "standard" public radio satellite channels and the "outside" channels leased to other users, although only the "standard" channels' data will be automatically downloaded to the computer via the DSC. Data for the "outside" channels will be sent to stations vai another method, and will have to be manually entered into the ARA at the station's computer.

The DSC also will provide two forms of timing synchronization data. One is a top-of-the-hour contact closure command, similar to that provided by the current system. This signal is delivered by one of the GPI outputs, selectable on the ARA set-up screen. More useful for stations with master clock systems (every station should have one, especially with the new PRSS) is time-sync data on the ARTIC card's data bus. Your master clock system's control-input software may have to be modified to accept this data, however.

Miscellaneous Interfaces

Like any computer-based system, AC power is also a critical element of interfacing. Clean, stable power is required, and a UPS (uninterruptible power supply) is highly recommended, at least for the PC. The demods have auto-ranging power supplies that can tolerate a fairly wide range of mains voltage, but a well-conditioned, transient-free power source is still advisable.

The demods also do a lot of digital processing in a small, one rack-unit (1 RU or 1-3/4") space, so heat dissipation is a factor. Their design allows the demods to be vertically stacked in a rack without interstices, but this is possible because a cooling fan is used in each unit. Seven or more of these fans running in a rack will generate some acoustical noise, which may create a problem for stations that plan to install their demods in critical acoustical spaces (such as a combo master control room).

Finally, the FISPO program will provide a fixed amount of equipment to all qualified stations, but additioal hardware will be available for purchase by stations (see Table 1 for prices). Some stations also may need to retain a portion of the current system's hardware for some time, depending on programming providers' transition schedules. The new hardware will be somewhat more space-efficient than the current system, but stations should allow sufficient space for growth and for duplication of hardware during transition period. This means a bit more space will probably be needed for satellite operations at most stations. The biggest difference in this respect is the move from dedicated controllers to "virtual" control via the supplied PC, which will have to be appropriately placed near the demods, probably on a tabletop rather than in a rack.

Summary

A quick review of the interfaces that will be required when installing the new PRSS includes the following areas:

• *Audio:* Your choice of analog, AES/EBU or MUSICAM signals must be run to switcher, distribution amplifier, console, rack and/or recorder inputs. (For AES/EBU runs beyond a few feet, special 110-ohm cable is recommended. Termination details also must be observed, similar to video distribution, because the AES/EBU signal requires about a 3MHz nominal bandwidth.)

Table 1: Additional hardware options for the new PRSS

Item	#Supplied Free	Addl. Units' Cost	Comments
Demod	7	$2,360	6 audio + 1 data
GPI	7	298	4 in, 4 out on each
I.F. Bus Selector	2	691	Each serves 8 demods
DACS Alarm Panel	1	322	Displays 8 alarms

• *Control:* The PC's ARTIC card will need to be connected to demods and GPIs (via RS-485), and the GPIs in turn will be hooked up (via twisted pair) to various station equipment and systems (possibly including device-control and status I/O on other computers running an automation/audio management system).

• *Data:* At the station's option, DACS and ARA data will need to be interfaced to a LAN (via a station-supplied network interface card on the SOSS workstation) or to other PC serial ports (via RS-232). Again, this may include a PC or LAN running an automation/audio management system. Timing data can also be interfaced to a station master clock system.

• *Telco:* The SOSS workstation's modem must be hooked up to a standard dial-up phone line. At the station's option, this line may or may not be routed through the station's PBX.

• *Power:* Well-conditioned power will be required, with a UPS recommended.

• *Physical:* Proper ventilation and attention to acoustical impacts (of computer and demod fan noise) will be required.

The new PRSS will usher in a small revolution in the way public radio programs are distributed. Its impact will be felt in improved audio quality, increased capacity, and greatly enhanced operations. But nothing worth having comes easily, as the saying goes. Public radio stations will have to exert appropriate design and installation efforts for the system to fulfill its complete potential.

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