

Testing a Digital-ATV Station using DVB-S

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Abstract

Most ham radio Amateur Television (ATV) stations and repeaters in use today still utilize analog technology. The purpose of this paper is to explain how to set-up and test a Digital-ATV (DATV) station to other hams...and to demonstrate the performance that can be achieved by using DATV. At the 2009 Digital Communications Conference, the authors presented a paper on “Planning a Digital-ATV Station for DVB-S”. Now, the authors present the results that were obtained by testing and using the DATV station they had planned. The testing by the authors demonstrated that DATV really does produce higher-quality video than analog-ATV under adverse conditions!!

Key Words

DATV Digital-ATV DVB-S QPSK MPEG-2 FEC Symbol-Rates RACES

1 - Introduction to DATV

For several years, the authors have listened to some interesting ham conversations about “...**we hams should change analog ATV over to Digital-ATV (aka DATV) to keep up with technology...**”. While the goal seemed simple, the topic was very complex and not easy to grasp. We found that there is still very little DATV activity in the United States – primarily the ATCO group (Amateur TV of Central Ohio). However, we found that there is a lot of experience with DATV in Europe and Australia. The European hams have written many good DATV articles that can be found on the internet...and are very willing share more information and answer our questions. This paper is our attempt to demonstrate that it really is straightforward to make the transition from analog-ATV to Digital-ATV.

Why Go Digital ATV?

The main benefits of digital ATV are:

- 1) The picture quality can be nearly perfect most of the time
- 2) Digital technology allows error correction from noise, multi-path
- 3) Digital techniques allow advanced modulation (less bandwidth) and compression
- 4) Digital TV components for hams will become more common on the marketplace.
- 5) Analog TV components for hams will start to disappear from the marketplace.

2 – Testing the DVB-S Exciter Boards

The block diagram in **Figure 1** shows the two main boards to produce a digital-ATV signal. The first board is the MPEG-2 Encoder board that accepts the analog camera video and audio and then (a) digitizes it and (b) compresses it. The digitized (but not yet compressed) video stream from an NTSC camera is about 168 Mbps. The MPEG-2 compressed video stream is typically selected to be from 2.0 Mbps to 2.5 Mbps. A data-bit-rate of about 2.5 Mbps is needed if there is lots of motion...think basketball game. Many hams report that 2.0 Mbps is sufficient for most ham-time video...where the motion is very limited. The second board in **Figure 1** is the DVB-S modulator...sometimes called the exciter. The DVB-S exciter board we purchased from SR-Systems in Germany provides the digital processing of (a) interleaving, (b) adding Forward Error Correction, (c) separating the data stream into I and Q data, and finally (d) feeding the I/Q data into a QPSK modulator with an RF output at 1.2 GHz.

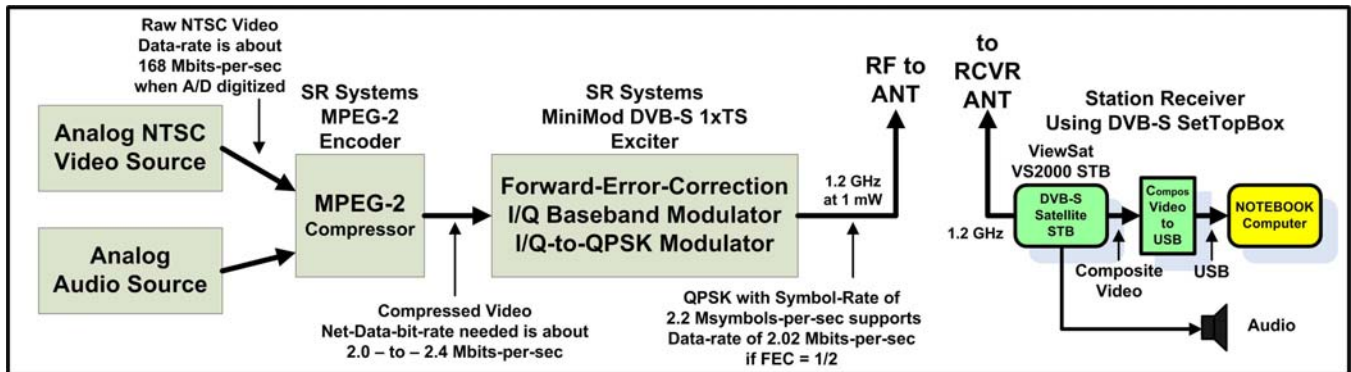


Figure 1 – Block Diagram Showing DATV Exciter being Tested

A photo of this first-bread board appears in **Figure 2**. The MiniMod-S exciter board has an output of about 1 milliwatt into a simple one-quarter wave vertical used for initial exciter testing.



Figure 2 – MPEG2 and DVB-S 1.2 GHz Exciter from SR-Systems on the Test “Breadboard”

2.1 - Configuring the DATV Transmitter

Choosing the transmitter frequency and all other setups and adjustments with the DVB-S transmitter and the MPEG2 compressor are made through an RS232 interface connected on the DVB-S Exciter board. I used a RS232-to-USB adapter to plug the RS232 cable into the notebook computer. By running a WindowsXP application called “HyperTerminal”, we can read out the settings on the boards and make changes to the settings. (NOTE – “HyperTerminal” no longer comes free with Window7. So we downloaded a free application from Microcross called “uCon” to communicate with the Exciter board.) **Figure 3** is a typical display of the settings menu as seen on the notebook computer.

```
DVB MiniMod Firmware V54.34 LOWDVBT
(c) 2009 maintech GmbH

OnBoard VCO: ADF4360-0
Real HF output range from 575000 to 1425000 kHz.
FPGA firmware v042.
Encoder firmware upload done (tvp5146,
0x01600425).

MiniMod Mainmenu
1) show status
2) Input Settings
3) Modulation Settings
4) Video Settings
5) Audio Settings
6) PSI Settings
7) PID Settings
> 3

Modulation Settings
1) TX Enable (ON AIR)
2) Output Frequency (1290000 kHz)
3) Spectrum (normal)
4) Carrier Only (no)
5) Output Gain (12)
6) Symbolrate (2500 ksym/s)
7) Coderate (FEC) (3/4)
0) exit menu
>
```

Figure 3 – Typical HyperTerminal Menu Display of the DVB-S Exciter Settings

2.2 - Configuring the DATV Receiver

The heart of the DATV receiving station is a ViewSat Model VS2000 Xtreme DVB-S SetTopBox (aka FTA or Free-to-Air) that I bought used on e-Bay. The price was right; less than \$75, including cost of shipping. As the block diagram in **Figure 1** shows, the output of the STB sends Composite Video to the USB port on the Dell notebook computer via Composite-Video-to-USB converter that costs about \$50 on the internet. I bought a Startech.com USB 2.0 converter (new) via Amazon. **Figure 4** shows a photo of the Startech.com USB 2.0 converter. Note that this model does not send the audio to the computer, only the composite-video signals or S-video. The Startech.com product is primarily designed to capture video files to a



Figure 4 – The Composite-Video-to-USB converter sends the STB Video to the Computer USB Port

disk on a computer and to take “snap shots” of video streams. The Startech.com product includes a software program called GrabBee that allows the USB data to be displayed on the computer screen. The computer screens in **Figure 5** and **Figure 6** are being displayed by the GrabBee application software and its device drivers.

The hardest part of our first testing session was to determine how to use the SetTopBox receiver to tune in the frequency we wanted, 1.290 GHz. This was not easy. Robbie determined from inspecting the STB menus that the STB local oscillator was 10,600 MHz. So, on this particular brand of STB:

$$\text{STB Search Freq} = \text{XMIT Freq} + 10,600 \text{ MHz}$$

$$\text{STB Search Freq} = 1290 \text{ MHz} + 10,600 \text{ MHz}$$

$$\text{STB Search Freq} = 11890 \text{ MHz}$$

Because each brand of STB has a different user’s interface...we could never determine how to command our STB to search-and-find our signal on a frequency of 11,890 MHz. So we tried a different approach and added a “new transponder” to the GALAXY 10R Satellite settings already on the STB. Now we could edit the frequency for the new transponder to 11890. **Figure 5** shows the settings for new ‘transponder 33’ is configured to 11890 with a Symbol-Rate (S/R) of 2500 (KSymbol/sec). During this first trial, FEC was selected as 3/4.

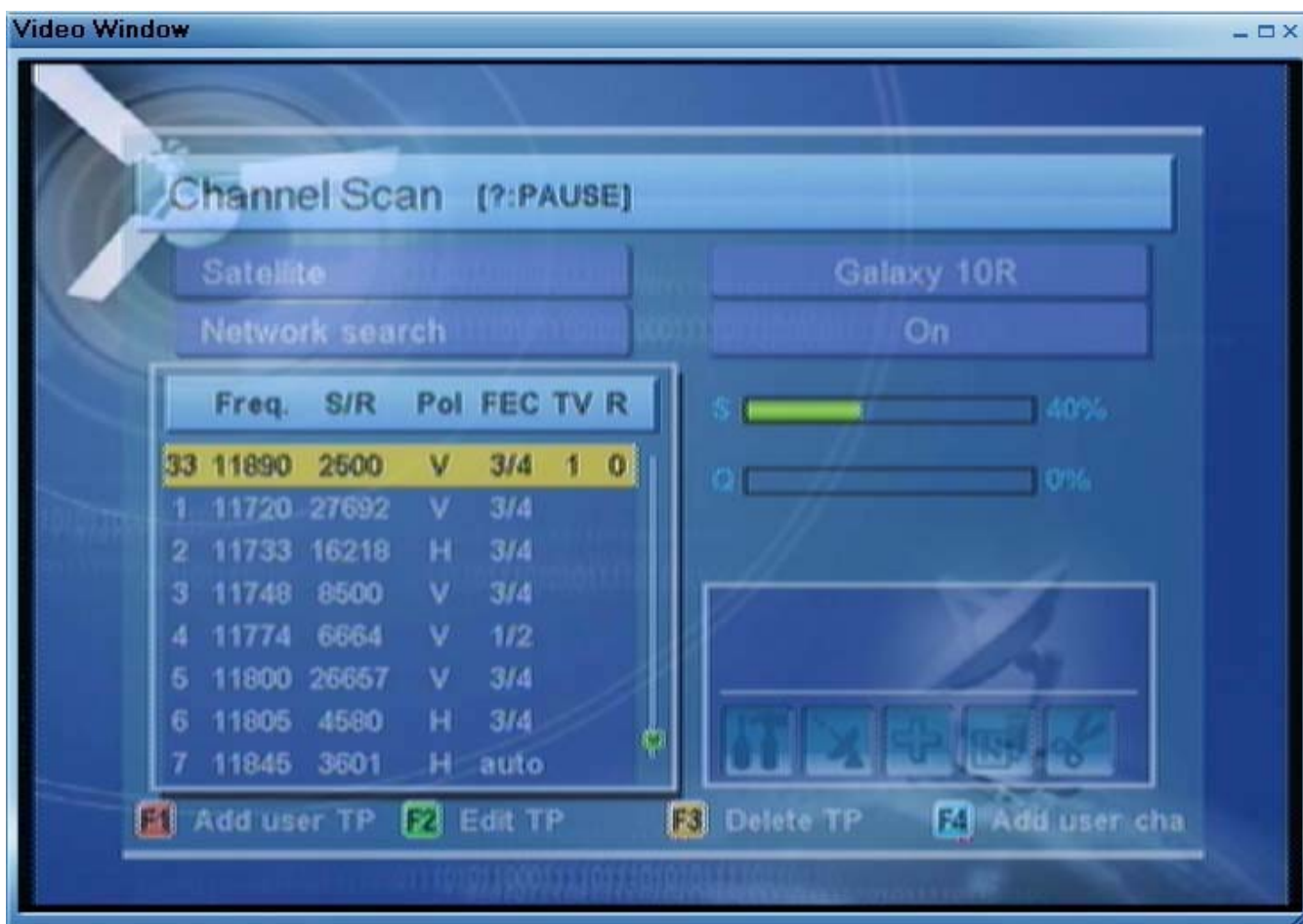


Figure 5 – The STB Configuration Menu for Editing Received Frequencies and other Settings

Robbie explained there are two cautions that hams need to take on the antenna connector of satellite STB's:

- 1) The center conductor of the antenna connector has a DC voltage present that is normally intended to power a remote LNB (low noise block) converter box near the satellite dish antenna. Do not short the center conductor to ground. The fuse is normally soldered down to the PCBA inside the STB (not an easy task to replace). Robbie installed a "DC Block" adapter to the antenna F-connector to prevent an accidental short circuit.
- 2) The STB receiver RF amplifier is quite sensitive and designed to receive tiny microWatt signals (-20 dBm to -70 dBm). We could blow out the STB amp if the received signal is too strong. For initial testing, Robbie inserted some 50 dB of attenuators on the antenna...knowing we could always remove the attenuators once we knew the value of signal strength.

2.3 - First DATV Test Pictures Received

Once we determined how to correctly configure a "transponder" setting for our frequency on the STB, the video picture magically appeared on the notebook screen...crystal clear!! A photo

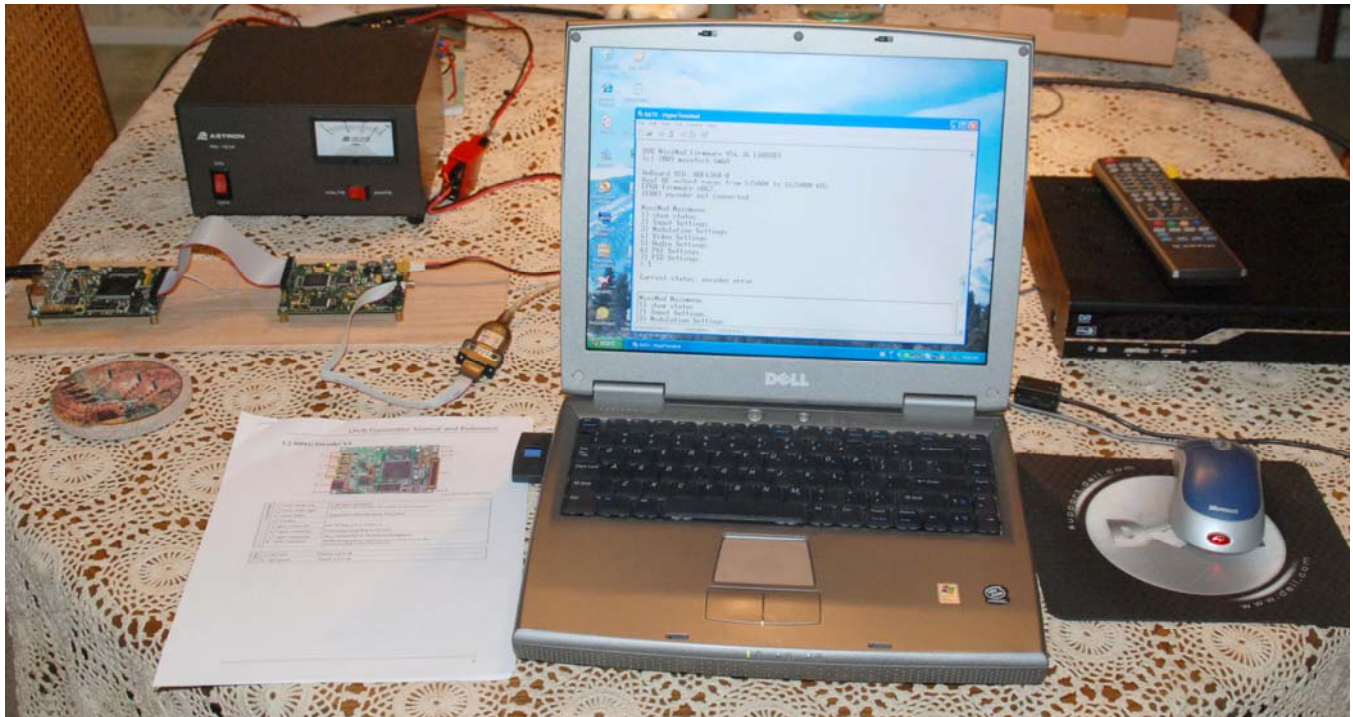


Figure 6 – Photo of the Entire DATV Station – Satellite STB receiver is on right, Notebook for configuring Transmitter in the middle, and DVB-S Transmitter on left.

of our first DATV test pictures is shown in **Figure 7**. To add a little professional touch to the received pictures, Robbie-KB6CJZ inserted his text generator in series with the video input to the MPEG2 encoder board. You can see “W6HHC ORANGE” show up in the upper-left corner of the DATV picture in **Figure 7**.



Figure 7 – First DATV Test Pictures (of Ken W6HHC) are Displayed on Dell Notebook Computer

The first thing that we noticed was that the audio had very little latency (delay) from real time. Probably about 1 second. For the first test trial, we had set the Symbol-Rate on the transmitter menu to 2.5 Msymb/sec and the MPEG2 data-bit-rate setting to “MANUAL” and 2.5 Mbits/sec, while FEC was set to 3/4. There was noticeable latency in the picture motion and also a noticeable “jerking” to the motion. We were confused to understand what was going on?? Why were we seeing so much video motion jerking??

The answer appeared while trying a little more testing at higher Symbol-Rates. When the GrabBee display software was set for default 720 pixel wide picture, the jerking was gone. When the GrabBee was set for a 1024 pixel wide picture (full screen), the jerking was extreme. The settings on the transmitter were NOT incorrect, but the receiving notebook computer and its display lacked the processing speed to convert the NTSC video pixels into a full display screen at 1024 pixels wide at the frame rate. The notebook computer was probably dropping five frames (or more?) to process one frame at 1024!! The picture also lost the jerkiness when the STB was connected to an analog TV as the monitor.

2.3 - Inspecting RF Bandwidth

Robbie used a HP Model 8559A Spectrum Analyzer 0.01-to-21 GHz plug-in (installed in a model HP 182T display) to determine the quality of the transmitted QPSK RF signals, as shown in **Fig 8**. The spectrum analyzer was set to 1.290 GHz – not centered, @500 KHz per /div (horizontal) and a bandwidth at 30 KHz. RF input was set at 0 dB with a two inch sniffer. Robbie checked the signals bandwidth which was reading about 3.5 MHz.



Figure 8 – Robbie-KB6CJZ Inspects RF Bandwidth with an HP Spectrum Analyzer

Last year, in our DCC 2009 DATV Planning presentation, the authors explained that the “allocation” bandwidth for QPSK (DVB-S) is predicted as:

$$\text{RF Bandwidth}_{(\text{allocation})} = 1.33 \times \text{Symbol-Rate}$$

$$\text{RF Bandwidth}_{(\text{allocation})} = 1.33 \times 2.5 \text{ MSymbols/sec}$$

$$\text{RF Bandwidth}_{(\text{allocation})} = 3.33 \text{ MHz signal}$$

So our measured bandwidth looked as expected. **Fig 9** shows the spectrum analyzer display of the DATV signal. The signal looked clean and did not drop out when the video was removed. No out-of-band testing or other testing was performed at this stage of testing.

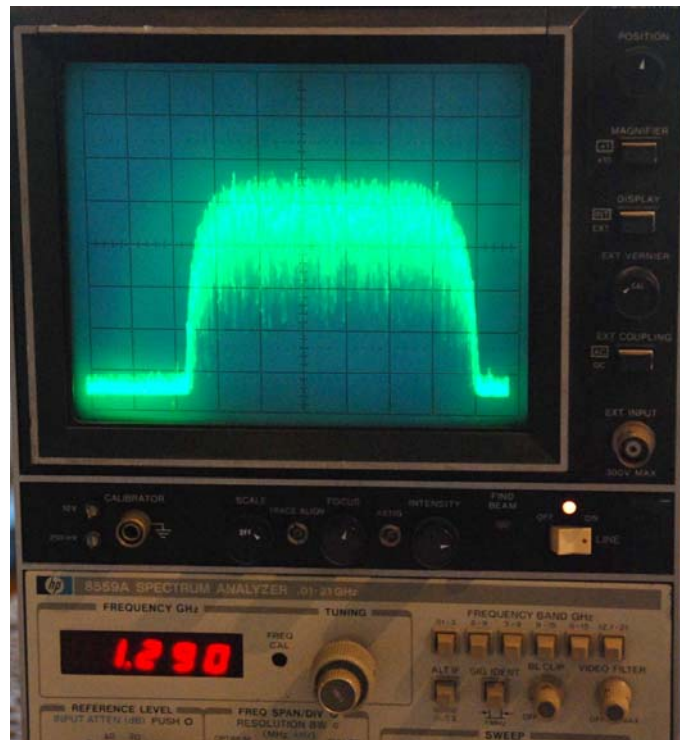


Figure 9 – A Close-up of the 1.290 GHz Signal RF Bandwidth on the HP Spectrum Analyzer Display

3 – Initial Field Test Demonstration for RACES

In October 2009, a county-wide RACES/MOU emergency communications drill was organized by the Orange County RACES (Radio Amateur Civil Emergency Service). The authors, with help from other members of the COAR RACES group in the City of Orange), conducted DATV tests by sending digital ATV pictures to the Orange PD RACES Radio Room and EOC (Emergency Operations Center). The authors believe this was the first use of DATV during a RACES operation in the United States.

We did not have enough time to complete testing of the RF Power Amplifiers for DATV, so the RACES testing of DATV was “jerry-rigged” using a portable 1 mWatt DVB-S transmitter that is

shown in **Fig 10** and **Fig 11**, This D-ATV transmitter is the same set-up used in Section 2. The portable DATV transmitting station used a 20- element 1.2 GHz yagi antenna.

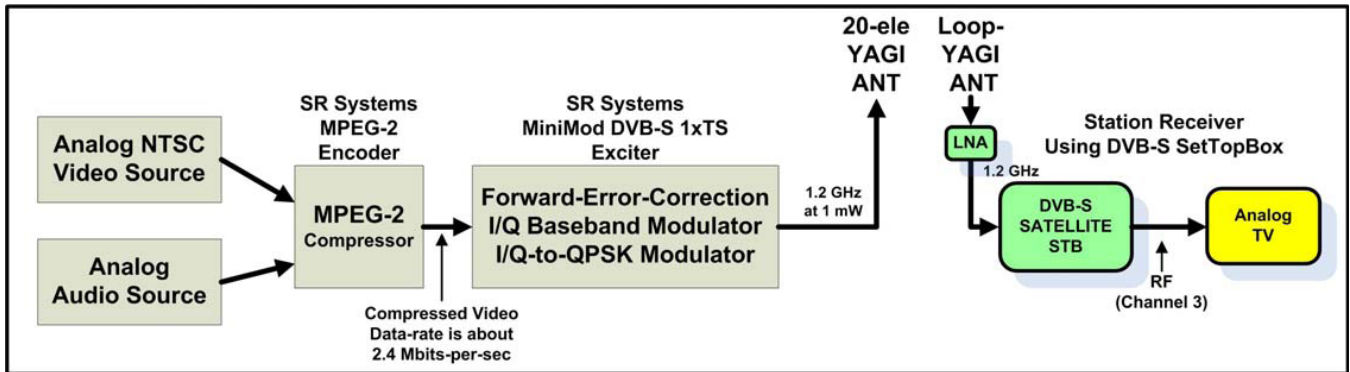


Figure 10 – Block Diagram Showing DATV Station for Initial Field Demonstration



Figure 11 – DATV DVB-S 1 mW Transmitter for 1.2 GHz

The receiving antenna was located on top of the Orange Police Department roof, near other RACES antennas normally used by COAR (City of Orange Amateur Radio) team. **Fig 12** shows Robbie-KB6CJZ adjusting the long 1.2 GHz loop-yagi antenna. A receiving Low-Noise-

Amplifier (LNA) was used and can be seen in the lower-right corner of **Fig 12**. The coax then took the signals down three stories to the COAR Radio Room.



Figure 12 – Robbie KB6CJZ adjusts the Receiver’s 1.2 GHz Loop-Yagi antenna

Fig 13 shows some of the radios and displays inside the OPD COAR RACES Radio Room. The lower display is an analog TV that shows the received DATV video directly. The larger display is also an analog TV that is connected to the network of large video LCD displays in the nearby City of Orange EOC room.



Figure 13 – Inside the COAR RACES Radio Room



Fig 14 – Cam-WV6V watches the DATV video stream being networked into the nearby Emergency Operations Center Room

Test Results

The video displayed inside the RACES Radio Room in **Fig 13** and **Fig 14** is being transmitted a distance of about 80-to-85 meters, from the far end of OPD parking lot. Not bad for 1 mWatt on 1.2 GHz!! In **Fig 14**, Cam-WV6V checks the DATV video quality that is now on the network that can be switched into the EOC room displays. The received video picture quality was great.

- **Picture Quality** - was perfect P5
- **Signal Strength** - was 3/4 scale on STB
- **Signal Quality** - was full scale on STB

In the preparation work for this RACES/MOU drill, Robbie-KB6CJZ had observed that the picture quality was either perfect or “blue screen” (aka “no picture”) as he drove around town. This is very characteristic of Digital-ATV that uses Forward-Error-Correction (FEC) to correct for noise or multipath distortion.

The authors were pleased with the results. While the distance for this test was small, the tests demonstrated to our RACES team that a DATV signal could be received at the Police Station and routed to the EOC video displays.

4 – Bench Testing the DATV Power Amplifiers

By early February, a first-stage (driver) power amplifier and a second-stage 30W power amplifier were added to complete the planned DATV station. A block diagram of the DATV station as it was configured is shown in **Fig 15**. Section 4 will cover bench testing the new power amplifiers and discuss information on receiving signals with different video resolutions.

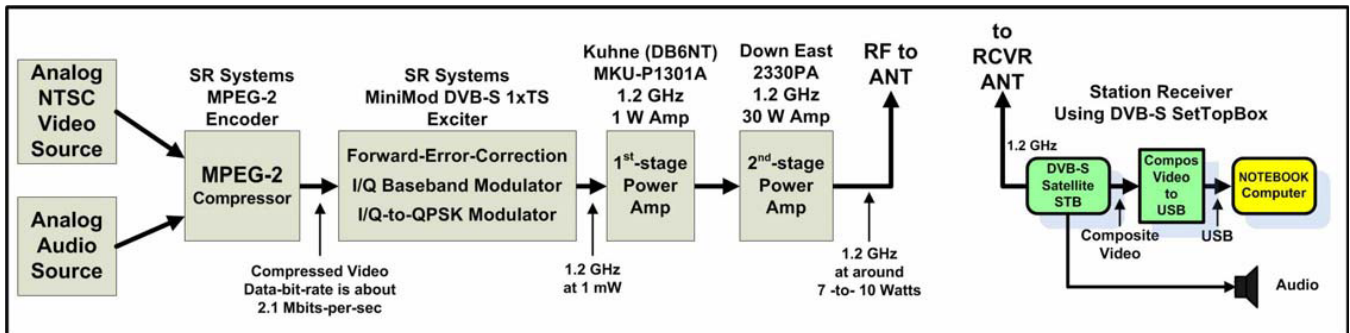


Figure 15 – Block Diagram Showing the Full DATV Station being Bench Tested

4.1 - First-Stage Power Amp

If you look at the block diagram in **Fig 15**, you will see that the first-stage 1.2 GHz PA chosen was the Kuhne model MKU-P1301A unit. We knew we wanted to use the Down East unit for stage-two...and we knew that Down East specified that their PA needed no more than about 25 mW to drive to full linear output levels. But, the SR-Sys MiniMod-S exciter output was only around 1 mW. So the 1 W Kuhne MKU-P1301A PA turned out to be a good choice. A little expensive, this 1W PA costs more than the Down East 30W unit, but it is a well-engineered PA for our purposes.



Figure 16 – Breadboard of MPEG-2 Board and MiniMod Exciter Board and the Kuhne 1st-Stage PA (on right side)

Fig 16 shows a photo of the exciter connected to the first-stage Power Amp on our “bread board” set-up. Notice that the Kuhne 1 W PA (on the far-right) is mounted on a thick aluminum plate that serves as a heat-spreader (aka “heatsink”). The Kuhne PA contains two internal voltage regulators to provide correct voltage to the power amp circuitry from the big 12V external power supply. These internal regulators draw a standby power of about 6 W.

When tested with an HP Model 432A microwave power meter, the Kuhne delivered plenty of output power for our needs. **Table 1** shows that we could get “measured average power” of over 300 mW output when driven hard by the exciter. **Fig 17** shows that the output signal of the Kuhne Power Amp was very clean (without spectral regrowth “shoulders”) even when being driven to the maximum by the exciter RF output settings.

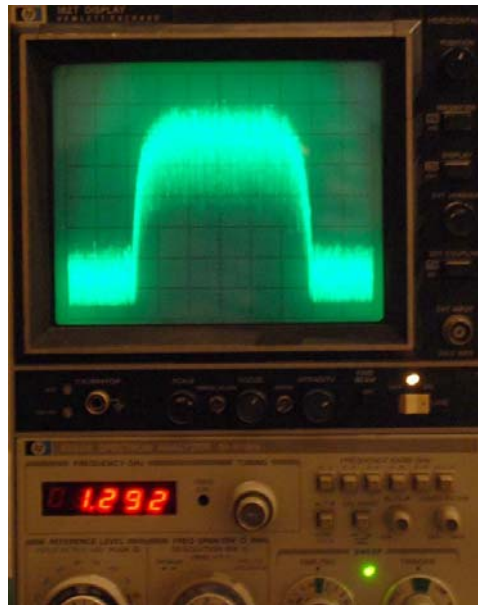


Figure 17 – HP Model 8559A Spectrum Analyzer looks at Kuhne first-stage PA output

Table 1 – Power Measurements taken during the DVB-S Station Testing

MiniMod-S exciter menu power setting	Measured MiniMod Output mW	Measured Kuhne 1st-amp Output mW	Measured Down East 2nd-amp Output dBm	Measured Down East 2nd-amp Output W	"shoulder" below main carrier
1	0.0661 mw	N/A	N/A	N/A	N/A
2	0.158 mw	N/A	37.6 dBm	5.75 W	35 dB
3	0.302 mw	N/A	39.7 dBm	9.33 W	32 dB
4	0.490 mw	N/A	41.8 dBm	15.1 W	29 dB
(Note: the readings below are with 5 dB attenuator between the first-PA and the second-PA)					
5	0.724 mw	N/A	38.0 dBm	6.31 W	34 dB
6	1.00 mw	N/A	39.3 dBm	8.51 W	32 dB
7	1.32 mw	N/A	40.3 dBm	10.7 W	31 dB
8	1.74 mw	115 mW	41.1 dBm	12.9 W	28 dB
9	2.24 mw	N/A	41.8 dBm	15.1 W	27 dB
10	2.63 mw	158 mW	42.3 dBm	17.0 W	25 dB

4.2 - Second-Stage Power Amp

The block diagram in **Fig 15** shows that the final-stage 1.2 GHz PA is a model 2330PA 30W unit from Down East Microwave (in Florida USA). **Fig 18** shows the rugged well-cooled construction of the Down East Power Amp. **Fig 19** shows the HP Model 432A Power Meter (a bolometer type of power meter) that was used for power measurements. Note the stack of precision attenuators at the top of **Fig 19** that are used to drop the power down close to 0 dBm for meter readings.

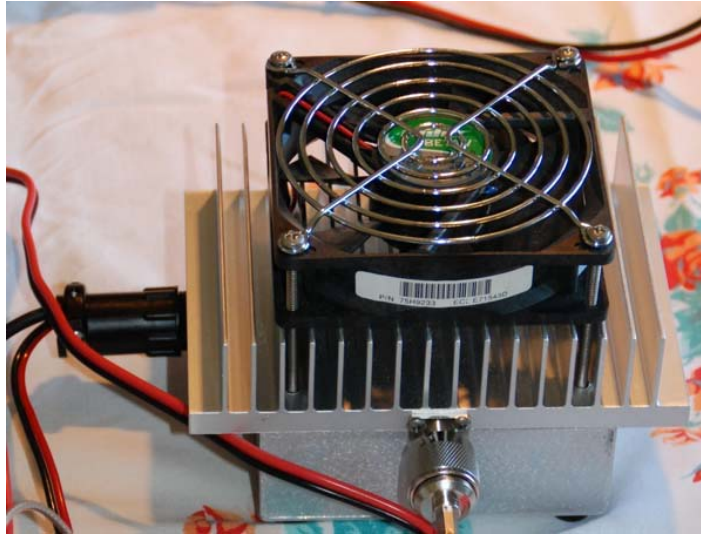


Figure 18 – Construction of Down East Model 2330PA Power Amplifier



Figure 19 – HP Model 432A Power Meter
Note the attenuator-stack at the top of the photo

Fig 20 shows the quality of the Down East PA output signal at around 13 W. The spectral regrowth shoulders are down about 28 dB from the main carrier signals. Power measurements are shown in **Table 1**. There is some uncertainty in the minds of the authors of the accuracy of

our power measurements. This HP power meter has not been calibrated for a few years. Also Tom WA8RMC who heads up the WR8RTV Digital repeater in Ohio, reports he appears to consistently obtain power measurements that are too high to be real. While bolometer type of power meter should measure the complex DATV signal properly, the newer digital analyzers like the Agilent VXA vector signal analyzer and the R&S model DVM400 Digital Video Measurement System are what commercial DTV stations use. DGØVE of Germany builds microwave RF amplifiers for hams. On the web site from Roberto (DGØVE) you can read (in German): “All [DGØVE] amplifiers can also be used for DVB-S and DVB-T with reduced power. You will notice that in the DVB-S mode only about 20% to 25% of the maximal output power (P-1dB) can be used [without distortion].” So in our case, The Down East PA is rated at 40W for FM (saturated), the “1db compression point” is 30W. So 25% of 30W is about 7.5W. This would lead us to believe that our 12.8W measured value is probably too high?

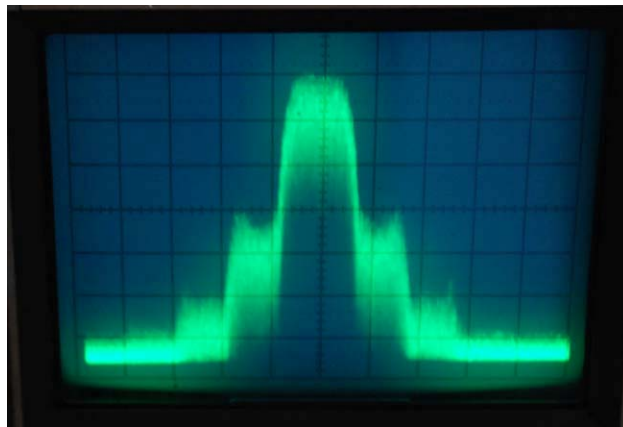


Figure 20 – HP Spectrum Analyzer looks at Down East output signal (shoulder about 28 dB down)

The reason that Alberto DGØVE recommends de-rating the power amplifier to 20% to 25% of the P-1dB value...is that QPSK has a high ratio of peak-power to average power. If you try to increase the average power higher...you will begin to compress the peaks and eventually “flat top” the peaks of power. Hans Hass DC8UE near Hamburg German, who has experience as a satellite communication engineer with a commercial DTV facility, explained to us that commercial stations work to keep the QPSK spectral regrowth distortion below 26 dB to avoid interference with adjacent channels. Our current guess is that we are probably running around 7 or 8 watts of “real” output power.

4.3 - Choices of Video Resolution

The User Documentation manual (English) that we had found on the SR-Systems web site for the MiniMod-S exciter did not go into depth concerning the configurations for video resolution that can be selected. The manual clearly shows that there are three choices for the transmitted DATV video:

- **D1**
- **HD1**
- **SIF**

But, what do these choices really mean? It took some Google searches to begin sorting out the puzzle and then finally we found a very good article by DJ1CU (called "The DVB-S 70 cm sender" in German) that is up on the www.DATV.de web site (under Projekte). Let's look at each of these three resolutions.

-- D1 Resolution --

D1 is the normal resolution that is used on a normal Standard-Definition Digital television (DVD quality).

- D1 = 720 x 576 Pixel for PAL
- D1 = 720 x 480 Pixel for NTSC

-- HD1 Resolution --

The HD1 resolution does NOT mean "High Definition". It turns out that HD1 really means "Half of D1".

- HD1 = 352 x 576 pixels for PAL
- HD1 = 352 x 480 pixels for NTSC

Volker-DJ1CU states that in his opinion HD1 resolution is perfectly acceptable for DATV.

-- SIF Resolution --

SIF stands for "Standard Input Format". It is related closely to CIF ("Common Interchange Format")

- SIF = 352 x 288 pixels for PAL
- SIF = 352 x 240 pixels for NTSC
- CIF = 352 x 288 pixels for PAL and for NTSC

DJ1CU states that in his opinion SIF is unacceptable for ordinary video transmission. Ken and Robbie used SIF for many tests. The main SIF problem is observed while displaying full screen video. Since you only have one-fourth of the video pixels...the display graphics needs to generate three more "phantom" pixels for every "real" pixel. What we could see in a full-screen video were that some pixels in the back-ground appeared to "flicker". The picture was clear...but the "phantom pixel flicker" was distracting.

Another impact of choosing the video resolution is that it determines the Net-Data-Bit-Rate (NDBR) coming out of the MPEG-2 encoder, and therefore affects the RF Bandwidth. A higher NDBR typically means a larger RF Bandwidth. DJ1CU reports:

Resolution	Video NDBR
D1	~2.0 Mbps
HD1	~1.1 Mbps
SIF	~0.5 Mbps

We used the D1 video resolution for our DATV bench testing.

4.4 - Digital-ATV "Latency"

During our first table-top tests in Section 2, we described that we had seen a latency (delay) of about 1 sec and that the video motion really got "jerky" (lost frames) if we displayed at full-screen on the notebook display. We needed to dig onto what were the causes.

We have determined that there are at least four primary potential-sources of latency involved with digital transmission/reception:

- **MPEG-2 Encoder**
- **SetTopBox Receiver (the Decoder)**
- **USB2 Video-Capture Board**
- **Graphics Processing in Notebook Display**

At the same time, Ken had read a DATV article that introduced him to new Hauppauge WinTV-HVR-1950 USB-based ATSC/NTSC/video-capture adapter. It had an external AC power adapter, so it had plenty of power for fast-processing. A series of tests were conducted to measure the DVB-S real-time delays from camera-to-display. The latency results are shown in **Table 2**. Let's look at each of these four areas of potential delays.

4.4.1 - MPEG-2 Encoder Delays

There is a lot of processing that goes on during the MPEG-2 encoding (compressing data) processing. While discussing latency with Stefan-DG8FAC of SR-Systems, Stefan explained that typically 90% of the latency that I was seeing going to an analog TV (Test #1 in **Table 2**) was occurring in the MPEG-2 board. Stefan stated "...The delays have nothing to do with the DVB-S Modulator/exciter, the delay is only generated by the MPEG-2 Chip on the Encoder board and the MPEG-2 Decoder that is in your SetTopBox...." We will see later when we discuss the SetTopBox, the SR-System MPEG-2 encoder board is generating about 1 second delay. Stefan explained that there is a "LowDelay Solution" for the encoder, but this encoder is very expensive, about 2500 Euro.

4.4.2 - SetTopBox Receiver Delays

Each frame of video requires 33 msec in NTSC. A quality STB will lag by about four frames (0.13 seconds) for the MPEG-2 decoding. A lot of inexpensive STBs have a delay of around 5-8 frames. The ViewSat VS2000 Xtreme STB is reported to be an excellent STB and we are inclined to believe it fits into the group of BOXes that exhibit "four frame delay". That means that the MPEG-2 Encoder board in Test #1 (see **Table 2**) has about a delay of ~1 second.

Table 2 – Measured DATV Latency Delays

Test	STB w/ Analog TV	STB w/ Dell Inspiron 1150 Notebook Intel 2.4 GHz CPU WinXP Pro	STB w/ Dell Precision M4400 Notebook Intel 3.1 GHz Core2 Win7 Pro	USB2 Video Capture board	NOTE
1	1.1 sec			(none used)	
2		1.2 sec	1.2 sec	Startech.com USB2	StarTech GrabBee lite display SW
3			2.47 sec	Hauppauge WinTV-HVR-1950	WinTV Ver 6 display software
4			2.8 sec	Hauppauge WinTV-HVR-1950	WinTV Ver 7 display software

4.4.3 - USB2 Video-Capture Delays

The low-cost StarTech.com USB2 video-capture adapter steals its power from the USB port on the computer. So, we knew that StarTech does not have a lot of power available for fast processing, a potential concern. However, **Table 2** clearly shows a measureable delay of about only 0.1 second being introduced by the StarTech.com USB2 unit. On the other hand, the newer Hauppauge WinTV-HVR-1950 video-capture unit, with its external power source,

introduced a delay of 1.37 second using Ver 6 of WinTV display software. With the newer (Win7 certified) Ver 7 WinTV display software and device driver, an internal delay of 1.7 seconds was measured....for a total latency of 2.8 seconds.

This Hauppauge HVR product was quite a disappointment for a DATV application, but OK for recording off-the-air TV broadcasts.

4.4.4 - Display Graphics Processing Delays

The old entry-level Dell notebook had simple graphics processing....just a “vanilla” Intel 82852/82855 Graphics Controller. The new Dell M4400 notebook has a powerful NVIDIA Quadro FX 370M6 Graphics Controller. The video “jerking” I had described on the older Dell, when displaying quarter-size SIF resolution to full-display-size, completely disappeared on the new faster Dell with the NVIDIA graphics.

5 – Field Testing the DATV Station

Bench testing is important. But we really get excited about seeing “proof of concept” by trying to send video signals across the town.

5.1 - Some Background

The authors are both members of the OCARC, but they are also members of the RACES emergency communications group for the City of Orange, called COAR (City of Orange Amateur Radio). For years, the COAR group had equipped itself with analog-ATV equipment intended to send field pictures to the city Emergency Operation Center (EOC) located inside the Orange Police Department building. But for years, COAR has been frustrated by the quality of the ATV pictures being received by the EOC. The 440 MHz analog-ATV quality was degraded because the signal path typically included elevated-freeways, 2-story residential homes, 1-to-3-story commercial buildings and a “forest” of backyard trees and tree-lined streets. The only good transmissions occurred if we parked the portable ATV transmitter on a hilltop with a clear signal path back to the Orange PD building.

Members of the COAR team had long speculated that perhaps Digital-ATV might provide the solution to improving the quality of our field video transmissions??

5.2 - The DATV Equipment used

Fig 21 is a block diagram of the set-up used during the recently completed field tests of DATV. The transmitter, and power amplifiers and SetTopBox (STB) receiver have all been described in more detail in Section 2 and Section 4.

Another ViewSat VS2000 DVB-S STB was purchased on eBay for installation inside the EOC Radio Room for the purpose of conducting these DATV field Tests. The eBay cost of this FTA STB unit was less than \$60 including shipping. **Fig 22** shows the new STB (bottom unit) being tested side-by-side to Ken W6HHC personal STB receiver before the field tests began.

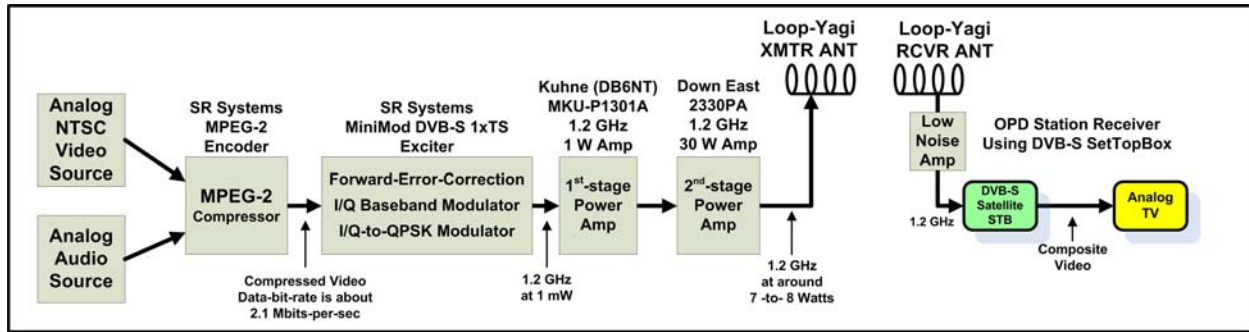


Figure 21 – Block Diagram of DVB-S Transmitter and Receiver for DATV Field Tests

The frequency used for the field tests was 1.292 GHz. Ken W6HHC had planned to set up the test frequency on 1.2915 GHz, but discovered that the STB menu would NOT allow him to enter 0.5 MHz digits. The Symbol-Rate was set to 2.2 MS/sec...producing an DVB-S RF BW_{allocated} of 3 MHz. The Forward Error Correction (FEC) was configured to 1/2.



Figure 22 – Bench testing the ViewSat STB that will be used at Orange PD

The receiving 1.2 GHz antenna (**Fig 23**) was a 24-element loop-Yagi antenna mounted at 3-stories high on top of the Orange Police Department building. The loop-Yagi antenna is made by Directive Systems (in Maine US). A Down East Microwave LNA for 1.2 GHz was installed for the field tests to drive the received DATV signal down 250+ feet of coax to the EOC Radio Room receiver.



Figure 23 – 1.2 GHz Loop-Yagi receiving antenna on roof of OPD

The field-transmitting antenna is also a 24-ele loop- Yagi from Directive Systems that Robbie KB6CJZ keeps in his closet of spare antennas. **Fig 24** shows a typical set up of the portable antenna during the field tests. The loop-Yagi is mounted on 25-feet of stacking masts purchased at Radio Shack..



Figure 24 – Bruce KC6DLA adjusts direction for the Field set-up of the 1.2 GHz Transmitting Loop-Yagi Antenna

5.3 - First Field Test – El Modena High School

The first DATV test site we chose, the parking lot of the El Modena High School, was picked because COAR RACES had tried analog-ATV tests on 440 MHz from this location two years earlier with extremely poor video quality... P1 or P2 at best. But P1 or P2 was not the video quality that COAR RACES wanted to show to the Police or Fire Chiefs or to the Mayor of the city in the EOC room. The test distance is only 4.5 miles, but includes an elevated freeway, three story apartment buildings, homes, 2-and-3-story commercial buildings, and plenty of trees.

While Robbie KB6CJZ and Steve KI6DDE operated the OPD receiving station, Ken W6HHC set up the DATV transmitting station in the back of his mini-van...see **Fig 25**. Just to be prepared, Ken also set up a STB receiver with a “sniffer” antenna and a notebook computer display to confirm that a video picture was actually being transmitted... if there was a lack of picture at the OPD. You can see the Notebook display in the center of the **Fig 25**.



Figure 25 – Field DATV transmitting station in back of MiniVan (the “sniffer receiver” display is seen in center)

Steve KI6DDE reported seeing a picture at the Police station from El Modena High School, even before Ken W6HHC could finish setting up his “sniffer” receiver. The picture was perfect!! Robbie KB6CJZ reported that the QUALITY monitor on the STB menu displayed 100%. **Fig 26** and **Fig 27** show the quality of the DATV signal that was received in the EOC Radio Room.



Figure 26 – First received DATV Video at the Orange PD

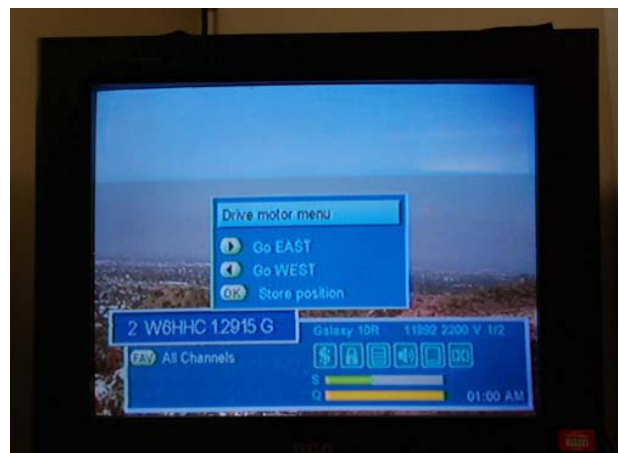


Figure 27 – The SetTopBox meter for QUALITY said 100%

5.4 - Second Field Test – AMTRAK Train Station

The second DATV test site we chose, the parking lot of the AMTRAK train station, was picked for two reasons. First, COAR RACES had also tried analog-ATV tests on 440 MHz from this location two years earlier with extremely poor video quality...just P1. The second reason, COAR had been asked to test DATV at an upcoming RACES drill for the city. We knew that we would be asked once again to supply video from the AMTRAK station during the RACES drill. The test distance is only 1.8 miles, but includes, 2-story commercial buildings, 3-story University buildings, homes, and plenty of trees. We had to aim the 1.2 GHz antenna right into a pair of large leafy trees, about 75 feet away.

A picture was reported at the EOC Radio Room as soon as the transmitter switch was turned on. Again Robbie reported the DATV picture was perfect and the SetTopBox QUALITY meter read 100%.



Figure 28 – Robbie KB6CJZ views received DATV Video inside EOC Radio Room



Figure 29 – Ken W6HHC keeps an eye on the DATV transmitter at the AMTRAK Field Testing Site

5.5 - Third Field Test – City “Mock EOC Drill”

The Police Department conducted the planned “mock EOC” drill for the City of Orange in order to test the abilities and training of Police Department volunteers, including COAR RACES communications volunteers to provide support for city EOC officials and staff and to provide communications from the field in a simulated train wreck incident. As expected, COAR was directed to provide DATV video from the simulated medical triage area in the parking lot of the Amtrak train station. A perfect DATV picture was being received at the EOC with only 10 minutes of travel time and 10 minutes to set-up the portable DATV equipment.

The received DATV signal was first displayed inside the EOC Radio Room. The video was then distributed to many large-screen LCD displays inside the EOC room itself, as shown in **Fig 30**. **Fig 26** shows the quality of the received video as seen on an analog CRT TV display. **Fig 31** shows the crisp clarity and quality of the DATV video distributed onto a large-screen digital display. Robbie KB6CJZ has commented that sweep-speeds and camera shutter speeds prevent these JPEG photos from really capturing the great quality he was actually seeing with his eyes on the CRT TV display. Robbie did notice that some pixilation occurred on DATV video when a fast moving bus passed quickly down the street within our field of vision.



Figure 30 – Live video as received in EOC RACES Drill is distributed to large-screen displays



Figure 31 – This close-up of a large-screen display in the EOC Room shows the clarity of received DATV.

6 - Conclusions and Plans

The authors learned a lot about different aspects of DATV during this project. We needed to dig into video resolution standards, better understand MPEG-2 latency, and develop a clearer understanding of the effect of peak-to-average power on de-rating a power amplifier for QPSK.

In overview, the authors and other COAR RACES members were very pleased with the DATV video quality they had obtained from our initial set of field tests. It was very encouraging to see DATV overcome the analog-ATV problems of multi-path reflections and weak signals. From the same locations that had been previously tried with 440 MHz analog-ATV with extremely poor results, COAR was now receiving 1.2 GHz Digital-ATV with really great video quality. **Digital-ATV really does produce higher-quality video than analog-ATV under adverse conditions!!**

The authors have plans to do more field testing to eliminate the slight pixilation situations seen in these first field tests. Perhaps a slightly higher Symbol-Rate...or an FEC setting with slightly less-redundancy might make a difference to reduce the observed pixilation. We used D1 video resolution in these tests. It will be interesting to compare quality of HD1 video resolution with D1 in an attempt to reduce the NDBR (payload) we need to support for a chosen Symbol-Rate.

It has been a fascinating journey for the authors to see our DATV project progress from just a study...to planning a station...to testing the station. Our DATV field-testing has really confirmed the robustness of the DVB-S Digital-ATV signals.

DATV - Referenced Links and Related Links

ARRL-TAPR DCC 2009 paper on "Planning a DATV Station on DVB-S"
www.TAPR.org/pub_dcc28.html

TAPR PSR Quarterly Journal Issue 111 on DVB-S Modulation Overview
www.TAPR.org/psr.html

Digital Video Broadcasting organization (DVB)
www.DVB.org

Amateur Television of Central Ohio
www.ATCO.TV

British ATV Club - Digital Forum
www.BATC.org.UK/forum/

British ATV Club - select from about 25 streaming repeaters
www.BATC.TV/

CQ-TV magazine from BATC (mostly analog)
www.BATC.org.uk/cq-tv/

Charles Brain-G4GUO blog on Software-Defined-Radio project for DATV
www.G4GUO.blogspot.com/

Darren Storer-G7LWT on "DATV / Digital Amateur Television Primer"
www.G7LWT.com/datv.html

DXzone Digital-ATV Links
www.dxzone.com/catalog/Operating_Modes/Digital_ATV/

Jean-François Fourcadier-F4DAY on "The POOR MAN's DIGITAL ATV TRANSMITTER"
pagesperso-orange.fr/jf.fourcadier/television/exciter/exciter_e.htm

Nick Sayer-N6QQQ blog on "Putting together an ATSC DATV station"
<http://nsayer.blogspot.com/search/label/ham>

Noel Matthews-G8GTZ on "The GB3HV digital project – part 1"
<http://www.g7lwt.com/documents/datv/GB3HV%20digital%20article1.pdf>

Orange County ARC complete series of newsletter DATV articles
www.W6ZE.org/DATV/

PE1JOK and PE1OBW on "The Ultimate Resource for Digital Amateur Television"
www.D-ATV.com

Rob Swinbank-MØDTS on details of "Poor Man's Digital ATV Transmitter – LIVE update"
www.M0DTS.co.uk/datv.htm

South West Herts UHF Group in UK
www.GB3BH.com

Thomas Sailer-HB9JNX/AE4WA, et al on "Digital Amateur TeleVision (D-ATV)"
www.baycom.org/~tom/ham/dcc2001/datv.pdf

Volker Broszeit DJ1CU article for "The DVB-S 70 cm Sender"
www.DATV.de/Projekte/projekte.html

AGAF D-ATV components (Boards)
www.datv-agaf.de and www.AGAF.de

DekTec PCI-card based modulator for DVB-S
www.DekTec.com/products/PciModulators.asp

DGØVE microwave amplifiers, up-converters, down-converters
www.DGØVE.de

Down East Microwave microwave amplifiers, low noise amplifiers (LNA)
www.DownEastMicrowave.com/

Kuhne Electronics (DB6NT) RF Amplifiers
www.Kuhne-Electronic.de

SR-Systems D-ATV components (Boards)
www.SR-systems.de

Typical Internet store for FTA DVB-S SetTopBox Receivers
www.GoSatellite.com