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# Fighting for M/H & 3D Dollars: Why 720p60 may rise again.

There are several reasons why 1080i TV broadcasters may now reconsider the 720p60 (59.94) OTA format for their prime HD (DTV) service, where the ATSC 6MHz channel will be "multiplexed" to include the emerging "profit-boosting" ATSC Mobile/Handheld services. Here's my analysis and opinion.

## The Winning OTA Format: 1080i or 720p?

All ATSC HD channels OTA are transmitted either in 1080i60 (59.94) or in 720p60 (59.94). Let's not get too technical. After years of demonstrations, most HDTV experts agree that 1080 interlaced and 720 progressive is perceived with the same resolution on the average, but with 720p being better in fast action sports and 1080i being better in slower moving scenes, on a typical home HDTV set in the 40 to 50-inch range.

Up to now, there has been no winning ATSC OTA HD format. CBS chose 1080i early, followed later by NBC. ABC and FOX chose 720p back in the late 1990s. So far, no TV Network has gained any major audience share just by their choice of HD format. But will that change in the future?

No one can deny that, in 2010, it is a progressive world with every new video and image service selecting a progressive format, including all of the ATSC M/H video formats.

## A New Business Model for the TV Station

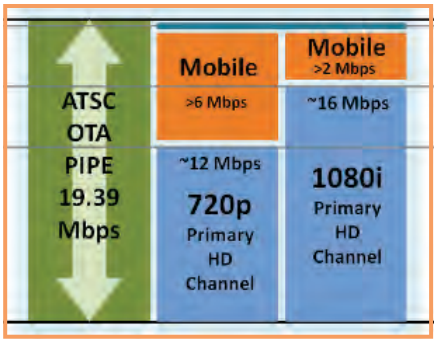
A TV station's local DTV transmitter coverage area is in most cases a circular market area with a radius of 50 or 60 miles, in many cases more.

Applying the "radius-square x 3.14", we get a huge coverage from just one ATSC/DTV transmitter location of perhaps 15,000 sq. miles or more.

The 6 MHZ OTA TV channel franchise seems again a great profit growth opportunity, if the local TV station can successfully develop HDTV, M/H and possibly other "one-to-many" metro-centric services.

## The ATSC 6 MHz OTA Pipe

The ATSC 8VSB modulation format can handle a total of 19.4 Mbps in the 6 MHz channel. In here lies the problem (or opportunity): MPEG-2 encoding technology is significantly more efficient in compressing progressive as compared with interlaced. For a given broadcast quality OTA HD signal, a MPEG-2 (ATSC) encoder requires about 16 Mbps minimum for 1080i while only about 12 Mbps for 720p. The TV station can potentially free up 4 Mbps of bandwidth for M/H and other services by converting from 1080i to 720p OTA.




Look at the above diagram, which approximately represents what the major TV Networks believe to be the minimum primary HD OTA bitrate for a major market TV station.

1080i60 consumes 16 Mbps, leaving only about 2 Mbps for M/H and the optional secondary SD channel, after allowing for PSIP/system data (~500 Kbps). But with 720p60 in the primary HD OTA channel at only 12 Mbps, about 6 Mbps is available for SD and M/H services.

## M/H & FEC Bitrate Demand

FEC or "Forward Error Correction" is required where the user must receive the message right the first time, as is the case in the one-way OTA broadcast. There is no return channel where the receiver can request an immediate resend of data, thus a highly robust "get-it-right-the first-time" transmission scheme must be designed and implemented. This requires heavy FEC.

FEC data may include repetition, error detection and correction data, always transmitted (whether needed or not) interleaved and substantially concurrent with the M/H payload data, to enable instant automatic correction of most errors encountered by the "roaming" mobile wireless devices. And because the M/H payload data is interleaved into the ATSC total OTA data stream, where the standardized legacy modulation is 8VSB (as opposed to "mobility friendly" COFDM), the additional FEC data rate for M/H is required to be extremely high, on the order of 3 times the data rate of the payload. The code rate efficiency is designed to be maximum 34% and minimum 17%. The code rate efficiency computations are very complicated, but for illustrative purposes in here, we use an average of about 25%.

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In other words, in a 720p60 OTA channel with (let's say) 6.5 Mbps available gross M/H space, only 25% or 1.6 Mbps can be M/H media payload.

In a 1080i60 OTA channel with (let's say) 2.5 Mbps available gross M/H space, the same 25% will ONLY amount to 0.63 Mbps (630 Kbps) for M/H payload.

## M/H Video Resolution

The ATSC M/H standard document A/153 specifies the base resolution of the video to be 416x240. Thus any HD or SD video is scaled down to 416x240 prior to being H.264 AVC compressed. Interlaced video (1080i and 480i) is de-interlaced prior to down-scaling. Note that A/153 provides for a wide range of progressive frame rates, from 12 fps up to 60 fps. Obviously, there is little or no need to use 60 fps for viewing on a 3-inch diagonal cell phone display. Thus, at the M/H base resolution of 416x240, maximum allowed frame rate is 30 fps.

The In-Car-Video display, mounted as a ceiling flip-down or in the seat backs or head rests (facing rear), may be up to 15-inches diagonally, with the viewers sitting quite close, almost like being in front of a PC monitor. Competing with program material sourced from DVD and Blu-Ray players, 416x240 at 30 fps is far from sufficient for the In-Car-Video displays.

A/153 provides for enhanced resolution mode at 624x360 and 832x480, with the frame rate range being from 12 fps up to 60 fps. Any such enhanced resolution mode shall use H.264 SVC compression (SVC = Scalable Video Codec) which basically compresses to the base layer of 416x230 and adds an enhancement layer on top with resulting 624x360 or 832x480 resolution. Smaller handheld devices (cell phones) receives the ATSC OTA transmission, detects and displays the 416x230 at up to 30 fps, while larger In-Car-Video displays detects and displays the 832x480 at up to 60 fps.

It is interesting to note that the 832x480 at 60 fps is substantially the 16:9 wide 960x480p60 format considered by some broadcasters in the late 1990s to be a quasi-HD ENG shooting format. It displays quite good on HDTV sets up to about 37 inches at normal home viewing distance.

## Compressed Bitrate for M/H Video?

Uncompressed bitrate for 416x240 at 30 fps at 8-bit 4:2:0 is about 36 Mbps. In other words, we are "scaling" about 1.1 Gbps (assuming studio quality 720p60 10-bit 4:2:2) down to 36 Mbps, or by an uncompressed factor of 30. Assuming H.264 AVC compression efficiencies at 416x240 equal to the efficiency at studio quality 720p60, the compressed base layer 416x240 will have a bitrate of less than 300 Kbps including compressed audio. If we reduce the frame rate to 12 fps, the bitrate may drop to less than 150 Kbps.

Using same logic for the 832x480 at 60 fps at 8-bit 4:2:0, the fully enhanced video has a total compressed bitrate of less than 1.6 Mbps including compressed audio.

Let's do 624x360 (at 60 fps at 8-bit 4:2:0) as well, by the same logic. Total compressed bitrate is less than 900 Kbps including compressed audio. If we half the frame rate to 30 fps, the compressed bitrate is less than 450 Kbps.

## The M/H Simulcast

To fully cover the M/H local market with simulcast of the primary HD OTA program, a reasonable compromise may be to use enhanced layering at 624x360p30 (which includes the base resolution 416x240p30 available to smaller mobile devices). The PDR (Payload Data Rate) is about 450 Kbps. Assuming an efficiency of about 25%, the MDLR (Main Data Rate Loss = total bitrate taken from your 19.39 Mbps ATSC OTA channel) is 1.834 Mbps according to the A/153 Efficiency Table.

**The 1080i TV Station Case**

A major network 1080i60 affiliate, currently having primary HD OTA at about 16 Mbps and a secondary SD OTA at about 2.5 Mbps, has NO bandwidth available for M/H service. To make room for M/H service, change options include:

- Reduce 1080i bitrate and quality
- Replace SD channel (with M/H)
- **Change HD OTA to 720p**

**The 720p TV Station Case**

A major network 720p60 affiliate, currently having primary HD OTA at about 12 Mbps and a secondary SD OTA at about 2.5 Mbps, has 3.5 Mbps of bandwidth available for M/H service. To make room for M/H service, NO change required. The 720p TV Station may slightly adjust the SD OTA and/or the HD OTA bitrate, and provide the 4-group M/H bandwidth of 3.667 Mbps (MDLR) to enable not only the M/H simulcast at 624x360 p30, but likely two additional 416x240 lower frame rate "cell phone channels". OR simulcast of both the HD and the SD OTA channels.

## Dominant Home HDTV Display Size

In 2009, more than 30 million flat screen HDTV sets were sold in the U.S., with more than 20 million of those having a display size 37 inches or smaller. About 10 million were 32-inch HDTVs. As more and more lower income families buy HDTVs, they may settle for smaller screens because of price. And the more affluent families now buying their second or third HDTV buy smaller screens as well for kitchens, kids room and bedrooms.

The average TV household HDTV display size is going down. Three years ago, the average was probably around 42 inches. By the end of 2010, the average display size of the installed HDTV base will probably end up at less than 37 inches.

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And for the vast majority of HDTV households, with HDTV display sizes at 37 inches or below, there is NO need to buy 1080p displays. 720p displays will more than suffice, even as HD displays for Blu-Ray players.

The author has four HDTVs at home. Admittedly, when I sit in front of my 52-inch 1080p60 LCD HDTV (and reasonably close), and I switch between the ABC local HD news in 720p and the CBS local HD news in 1080i (both then received ATSC OTA), I can spot a higher resolution on the 1080i presentation. But it is really only because the local stations' news sets are like "still pictures" and I know what to look for. Both the 720p and the 1080i are spectacular. When I do the same test with my 37-inch 720p bedroom set (hanging from the ceiling—the HDTV, that is!) there is obviously no perceived difference, as my 37-inch HDTV is 720p. But, even if the 37-inch set was 1080p, there would be no perceived difference by an average home viewer.

### OTA Broadcast of 1080p60?

This dream now seems over. At least for many years to come. Between the FCC Broadband Plan and ATSC M/H, a change from ATSC 8VSB/MPEG-2 to "ATSC COFDM/H.264" seems very distant at this time. One of the early reasons by some TV Networks for selecting 1080i60 over 720p60 was that 1080p60 was on the "not-so-distant-horizon" and that 1080i would be an easier conversion to 1080p than 720p. One of the two major Japan-based HD broadcast equipment suppliers boldly and actively supported 720p, while the other one refused to acknowledge 720p for many years. Was there pressure from NHK? From any U.S. TV Network? Some of us know the story.

It is reasonably clear that OTA broadcast of 1080p60 over the DTV channels is not likely to happen, thus 1080i can no longer be justified by 1080p being on the DTV OTA horizon, when 720p clearly offers distinct financial advantages over the next many years.

### What is the financial justification for staying with OTA 1080i60?

We are talking Over-the-Air (OTA), and not a wholesale conversion from 1080i infra-structure to 720p for 1080i TV stations. All that is needed is the high quality real-time de-interlacing and conversion from 1080i to 720p before the ATSC MPEG-2 encoding and transmitter chain. Many TV Stations can probably just flip a switch on the ATSC encoder, after installing one or more high end format converters.

By doing so, the TV Station may open up an additional 4 Mbps for M/H services and secondary SD channel. While maintaining broadcast quality HD delivery to the HDTV households.

Beside the requirement to purchase the necessary de-interlacing and format converter equipment, and some support products, is there any audience or financial market justification for staying with 1080i OTA in 2010? We cannot see any.

Did any TV Station gain DMA audience success because of operating with 1080i rather than 720p, or 720p rather than 1080i? We don't think so.

Those choices were made more than 10 years ago by the TV Networks, long before the days of serious ATSC M/H discussions, not to mention the FCC Broadband Plan, at that time evaluating available and emerging HD technology, ease of TV Station SD-to-HD conversion and perhaps the preferred subjective choices of engineering executives, some now retired. And the O&O as well as the affiliated stations were required to follow the TV Networks format choice. ATSC M/H is now making "follow the TV Network" much less relevant, as M/H may present real financial reasons favoring 720p60 OTA over 1080i60.

### The Financial Reasons for 720p60 OTA

**Open up 4 Mbps for M/H**

The TV Station may get a total of about 6.5 Mbps of OTA bandwidth for M/H, above the 12 Mbps assigned to the 720p60 DTV channel. To compete in any local market against independent non-affiliated DTV stations, whereindependents may accept lesser quality of the HD channel to favor multiple M/H services, will be very difficult unless the 6+ Mbps OTA bandwidth is available. Although, any major TV Network affiliated station cannot unduly compromise its primary HD OTA quality.

**Easy Progressive Scaling: From 720p60 to M/H formats**

Your OTA conversion to 720p60 before your ATSC encoder/transmitter chain requires high quality de-interlacing and format conversion. Easy progressive scaling to M/H simulcast and web is then available.

**More Cost Effective HD ENG**

Shooting, editing and backhauling 720p60 is more cost effective than 1080i. One major TV broadcast equipment supplier (JVC — Author is a paid consultant to JVC from time to time) offers a format called ProHD, which includes a range of professional HD camcorders intended for HD ENG and based on a native 1280x720p60 3x 1/3" CCD front end.

Because each 720p pixel area is more than 2x larger than the equivalent 1080i pixel area (identical size sensor), the ProHD camcorders offers exceptional low light performance, comparable to 1080i with 1/2" CCD front ends.

Because of the progressive 720 format, the ProHD's super-compressor achieves broadcast quality HD ENG signal at only 19 Mbps, which in turn makes the microwave HD backhaul highly cost effective.

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## New Hyperlocal News: Shoot in 720p60

The latest local (or Metro-centric) activities of TV Stations around the country involves "Hyperlocal News & Interest Coverage" where a larger metropolitan area (i.e. Seattle is one) is divided into as much as 40 "hyperlocal" neighborhoods, and where volunteers and part time paid hyperlocal journalists are interleaving Metro-centric coverage with hyperlocal news on micro websites, each "vertically addressing" a few thousand hyperlocal residents rather than a metro-wide million plus. Shooting hyperlocal news in 720p60 is the ideal format for down-scaling to M/H and internet video, while at the same time having native quality HD matching the DTV OTA 720p60.

## 3D requires Progressive

Without going into details, 3D formatted HD transmissions require separate left and right channels. Interlaced 1080i60 can indeed be the delivery format for separate left and right views, where (for example) the odd lines carry the left eye images and the even lines carry the right eye images, and using either polarized passive glasses or active shutter glasses depending on the 3D system. However, 1080i60 means that we have alternating (interlaced) views with each eye seeing 1980 pixels across x 540 lines 30 times per second. This produces perceived flicker which can be cured by today's 120 and 240 Hz refresh rate HDTV sets. 1080p60 on the other hand, using alternating frame switching for left and right, delivers 1980 pixels across x 1080 lines for each eye 30 times per second, using active shutter glasses, and increasing the refresh rate in the 3D HDTV to 120Hz (60Hz for each eye) eliminating flicker and improving spatial resolution by each eye being presented a full HD image.

But . . . 1080p60 3D delivery format is obviously NOT possible over ATSC OTA, as 1080p60 is currently NOT permitted in the ATSC table, due to insufficient bandwidth.

## ATSC OTA 3D using 720p60 for home delivery?

But, as obvious, 720p60 is indeed available, and using the logic presented earlier in this Report, that 720p60's perceived HD resolution is quite sufficient on the vast majority of home HDTVs, 720p60 can indeed be used for ATSC OTA 3D delivery.

Let's remember that 60 frame progressive is really good for fast action i.e. sports. Also, 3D presentations on home HDTVs may not be produced as "exaggerated or dramatic" as presented in a 3D Cinema venue, due to the home screen sizes being proportionally much smaller than cinema screens (a more narrow field of view of the total screen width at home). This supports a 720p60 3D system using active shutter glasses, where alternating frames delivered successively to the left and right eyes, with each eye seeing full 1280x720 at native 30 frames per second, which may easily be doubled for each eye by a 120Hz-capable home HDTV. NOTE that with 1080i60 as 3D OTA delivery vehicle, each eye only sees 540 lines, while with 720p60, each eye sees 720 lines.

**There are challenges to achieving such a 720p60-3D OTA system:**

1. Permission by the FCC (?)

2. The availability of a 720p 3D encoder/processor capable of delivering the encoded left-right alternating frame signal to the 8VSB ATSC modulator (initially we would anticipate that any such 720p-3D material will be delivered to the TV station as a pre-encoded/processed file, ready to be "served" to the OTA chain)

3. The availability of an ATSC 8VSB modulator able to modulate the 720p-3D signal without complications

4. The availability of a 3D-HDTV consumer set capable of receiving, decoding and displaying the 720p-3D OTA

There is no "reasonable" reason why the FCC should deny such service, at least at the trial level. A key area of FCC concern would probably be "to serve the public interest". Challenges 2 & 3 listed above are technical, for which solutions are within reach. Challenge 4 is a CE supplier issue, which is much more market/financial oriented than technical. Another solution is to modify an ATSC OTA STB to receive and convert the 720p-3D signal to a HDMI 3D output compatible with major CE suppliers' 3D-HDTV sets.

## "Watch" the Independents!

Is this the time of opportunity for the non-network-affiliated local TV stations to make a play for increased local market share? Network affiliated stations are largely controlled by Group Station Owners capable of making timely decision, unless limited by affiliate agreements as to formats and services. O&Os are of course generally fully controlled by the major networks. The Independents can make fast decisions, and may be approached by several broadcast outsiders to take advantage of the great current opportunities in M/H and 3D.

## Conclusion

In the new ATSC world of M/H, live HD ENG, Hyperlocal News, 3D and the 37-inch average dominant HDTV display, we cannot uncover any real reason why a TV Station should try avoid the OTA conversion from 1080i60 to 720p60 for the purpose of significantly increasing OTA M/H bandwidth, and to be ready for a possible 3D OTA world.