

Getting the Shot: Advanced MPEG-4 AVC Encoding and Robust COFDM Modulation Deliver HD-ENG

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Problem Overview

- Migration of news gathering feeds from SD to HD introduce capacity and performance challenges for RF channels using existing picture coding and modulation technologies
 - MPEG-2 picture coding
 - 4.5Mbps – 8Mbps provides acceptable SD contribution picture quality
 - 14Mbps – 18Mbps provides acceptable HD contribution picture quality
 - DVB modulation
 - DVB-S provides robust transmission using QPSK, FEC=3/4
 - ~6.0Mbps data rate for a 5.5MHz satellite channel
 - DVB-T provides robust transmission using QPSK, FEC=1/2, GI=1/8
 - ~5.5Mbps data rate for a 8MHz terrestrial channel
 - Both are sufficient for MPEG-2 SD but not for MPEG-2 HD!
- Furthermore, in the USA, BAS channel relocation has reduced bandwidth available for terrestrial news gathering
 - 17MHz channel bandwidth reduced to 12MHz
 - Dual 8MHz channels (pedestals) are no longer possible

Solution Overview

■ HD news gathering requires new solutions

■ Satellite News Gathering (HD-SNG)

- DVB-S2 provides ~30% bandwidth improvement over DVB-S
 - Robust transmission using higher order constellations and stronger FEC
 - 8PSK, FEC=3/4 provides 11.14Mbps data rate for a 6MHz satellite channel
- MPEG-4 AVC provides excellent HD picture quality for news at half the bit-rate or less of MPEG-2
 - 6Mbps – 10Mbps can easily be accommodated in 4.0MHz – 6.0MHz channels
 - Allows HD-SNG in the same bandwidth as SD-SNG

■ terrestrial Electronic News Gathering (HD-ENG)

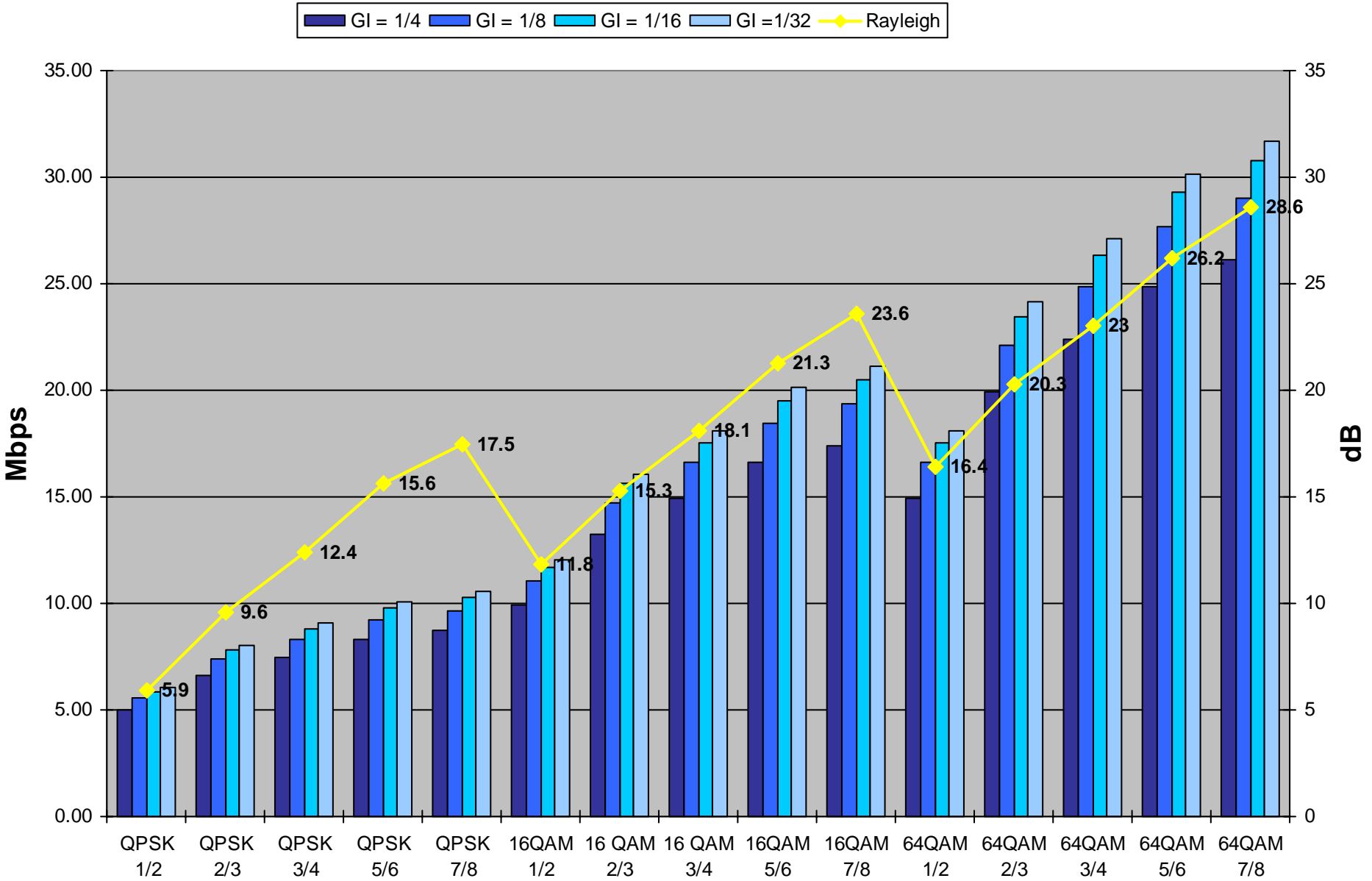
- DVB-T2 spec is ready but not yet commercialized
 - DVB-S2 type of FEC (LDPC & BCH) will increase payload by 30% over DVB-T
- Two challenges for HD-ENG using current DVB-T technology
 - Provide good picture quality using robust modulation parameters
 - Provide acceptable picture quality to support 6MHz pedestal
 - **Only MPEG-4 AVC can provide acceptable HD picture quality under these conditions!**
- Achieving the above goals will allow news to recover its pre-BAS, pre-HD field production capabilities
 - High confidence in “getting the shot”
 - Ability to transmit multiple HD feeds in a single channel

DVB-T Channel CNR and Data Rate Table for 8MHz

Modulation		CNR (dB) required for BER = 2×10^{-4} after FEC			Data Rates (Mbps) for an 8MHz Channel			
Constellation	FEC	Channel Type			Guard Interval			
		Gaussian	Ricean	Rayleigh	1/4	1/8	1/16	1/32
QPSK	1/2	3.5	4.1	5.9	4.98	5.53	5.85	6.03
QPSK	2/3	5.3	6.1	9.6	6.64	7.37	7.81	8.04
QPSK	3/4	6.3	7.2	12.4	7.46	8.29	8.78	9.05
QPSK	5/6	7.3	8.5	15.6	8.29	9.22	9.76	10.05
QPSK	7/8	7.9	9.2	17.5	8.71	9.68	10.25	10.56
16QAM	1/2	9.3	9.8	11.8	9.95	11.06	11.71	12.06
16QAM	2/3	11.4	12.1	15.3	13.27	14.75	15.61	16.09
16QAM	3/4	12.6	13.4	18.1	14.93	16.59	17.56	18.10
16QAM	5/6	13.8	14.8	21.3	16.59	18.43	19.52	20.11
16QAM	7/8	14.4	15.7	23.6	17.42	19.35	20.49	21.11
64QAM	1/2	13.8	14.3	16.4	14.93	16.59	17.56	18.10
64QAM	2/3	16.7	17.3	20.3	19.91	22.12	23.42	24.13
64QAM	3/4	18.2	18.9	23.0	22.39	24.88	26.35	27.14
64QAM	5/6	19.4	20.4	26.2	24.88	27.65	29.27	30.16
64QAM	7/8	20.2	21.3	28.6	26.13	29.03	30.74	31.67

- Gaussian Channel: Line-of-Sight (LoS) signal w/no signal echoes (AWGN-only)
- Ricean Channel: High-power LoS signal plus low-power signal echoes of varying level and phase
- Rayleigh Channel: High-power signal echoes w/low-power or no LoS signal

Rayleigh Channel CNR and Data Rate Graph for 8MHz

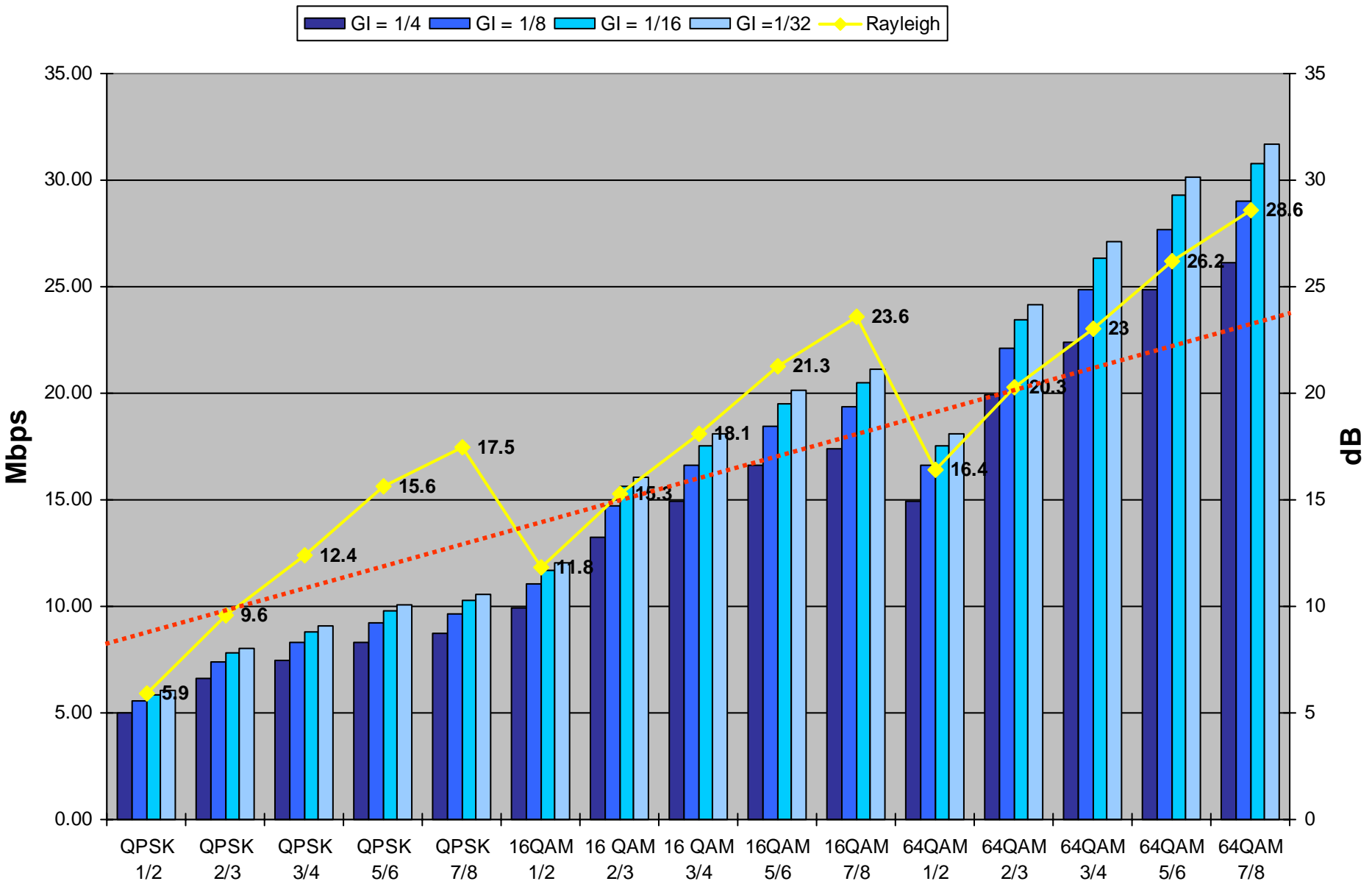


Solution Criteria

■ Selecting optimal modulator operating point

- Higher constellations increase data rate and CNR
 - For similar FEC (see DVB-T Table)
 - Data rates: 16QAM = 2xQPSK, 64QAM = 3xQPSK
 - Rayleigh CNR increases by ~6dB from QPSK to 16QAM and by another ~6dB from 16QAM to 64QAM
- Lower FEC increases data rate and CNR
 - For similar constellation (See DVB-T Table)
 - Data rate increases as FEC_L / FEC_H e.g. $(7/8) / (1/2) = 7/4$
 - But Rayleigh Channel CNR increases by ~12dB from FEC=1/2 to FEC=7/8!
- **Solution!** More FEC at higher constellation provides lower CNR and higher payload compared to less FEC at lower constellation in Rayleigh Channel (multi-path) environments
 - Examples
 - 16QAM, FEC=1/2 has CNR=11.8dB, payload of 11.06Mbps @ GI=1/8 versus QPSK, FEC=7/8, has CNR=17.5dB, payload of 9.68Mbps @ GI=1/8
 - 64QAM, FEC=2/3 has CNR of 20.3dB, payload of 23.42Mbps @ GI=1/16 versus 16QAM, FEC=7/8 has CNR of 23.6dB, payload of 20.49 @ GI=1/16

Rayleigh Channel Operating Solutions for 8MHz



Rayleigh Channel Operating Points for 8MHz

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QPSK	3/4	6.3	7.2	12.4	7.46	8.29	8.78	9.05
QPSK	5/6	7.3	8.5	15.6	8.29	9.22	9.76	10.05
QPSK	7/8	7.9	9.2	17.5	8.71	9.68	10.25	10.56
16QAM	1/2	9.3	9.8	11.8	9.95	11.06	11.71	12.06
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■ DVB-T Transmission Characteristics for 8MHz Channel

- 16QAM, FEC=1/2, GI=1/8 operating point
 - Provides optimal balance between channel and payload performance
 - Rayleigh Channel CNR of 11.8dB is sufficiently robust for most multi-path environments
 - 11.06Mbps data rate provides very good picture quality @ 10.0Mbps
 - Provides “good-fit” to 11.14Mbps data rate of a 6MHz SNG channel using DVB-S2 operating point of 8PSK, FEC=3/4
- QPSK, FEC=2/3, GI=1/8 operating point
 - Provides improved multi-path performance
 - Rayleigh Channel CNR of 9.6dB for severe multi-path in urban environments
 - 7.37Mbps data rate provides good picture quality @ 6.3Mbps
 - Provides “good-fit” to 7.42Mbps data rate of a 4MHz SNG channel using DVB-S2 operating point of 8PSK, FEC=3/4
- 64QAM, FEC=2/3, GI=1/16 operating point
 - Provides much higher payload
 - 23.42Mbps data rate provides ~23.1Mbps payload
 - Allows multiplexing of two or more video feeds in a single pedestal or
 - Multiplexing of high IP (file) data traffic w/a single video feed
 - Rayleigh Channel CNR of 20.3dB for moderate multi-path environments

Recommended Operating Points for 8MHz Channel

DVB-T Data Rate Tables (in Mbps)

	8MHz Channel											
	1/4 Guard Interval			1/8 Guard Interval			1/16 Guard Interval			1/32 Guard Interval		
FEC	QPSK	16QAM	64QAM	QPSK	16QAM	64QAM	QPSK	16QAM	64QAM	QPSK	16QAM	64QAM
1/2	4.98	9.95	14.93	5.53	11.06	16.59	5.85	11.71	17.56	6.03	12.06	18.10
2/3	6.64	13.27	19.91	7.37	14.75	22.12	7.81	15.61	23.42	8.04	16.09	24.13
3/4	7.46	14.93	22.39	8.29	16.59	24.88	8.78	17.56	26.35	9.05	18.10	27.14
5/6	8.29	16.59	24.88	9.22	18.43	27.65	9.76	19.52	29.27	10.05	20.11	30.16
7/8	8.71	17.42	26.13	9.68	19.35	29.03	10.25	20.49	30.74	10.56	21.11	31.67

Recommended Operating Presents for 8MHz Channel

Recommended Operating Presets for 8MHz Channel using Fujitsu IP-9500 MPEG-4 AVC Encoder

Preset	Mod	FEC	GI	Mod Data Rate	TS Bit Rate*	Video Bit Rate	Audio Bit Rate
6	QPSK	2/3	1/8	7.37Mbps	7.0Mbps	6.3Mbps	64Kbps
7	16QAM	1/2	1/8	11.06Mbps	10.7Mbps	10.0Mbps	64Kbps
8	16QAM	2/3	1/8	14.75Mbps	14.4Mbps	13.7Mbps	64Kbps
9	64QAM	1/2	1/16	17.56Mbps	17.2Mbps	16.0Mbps	512Kbps
10	64QAM	2/3	1/16	23.42Mbps	20.7Mbps	20.0Mbps	512Kbps

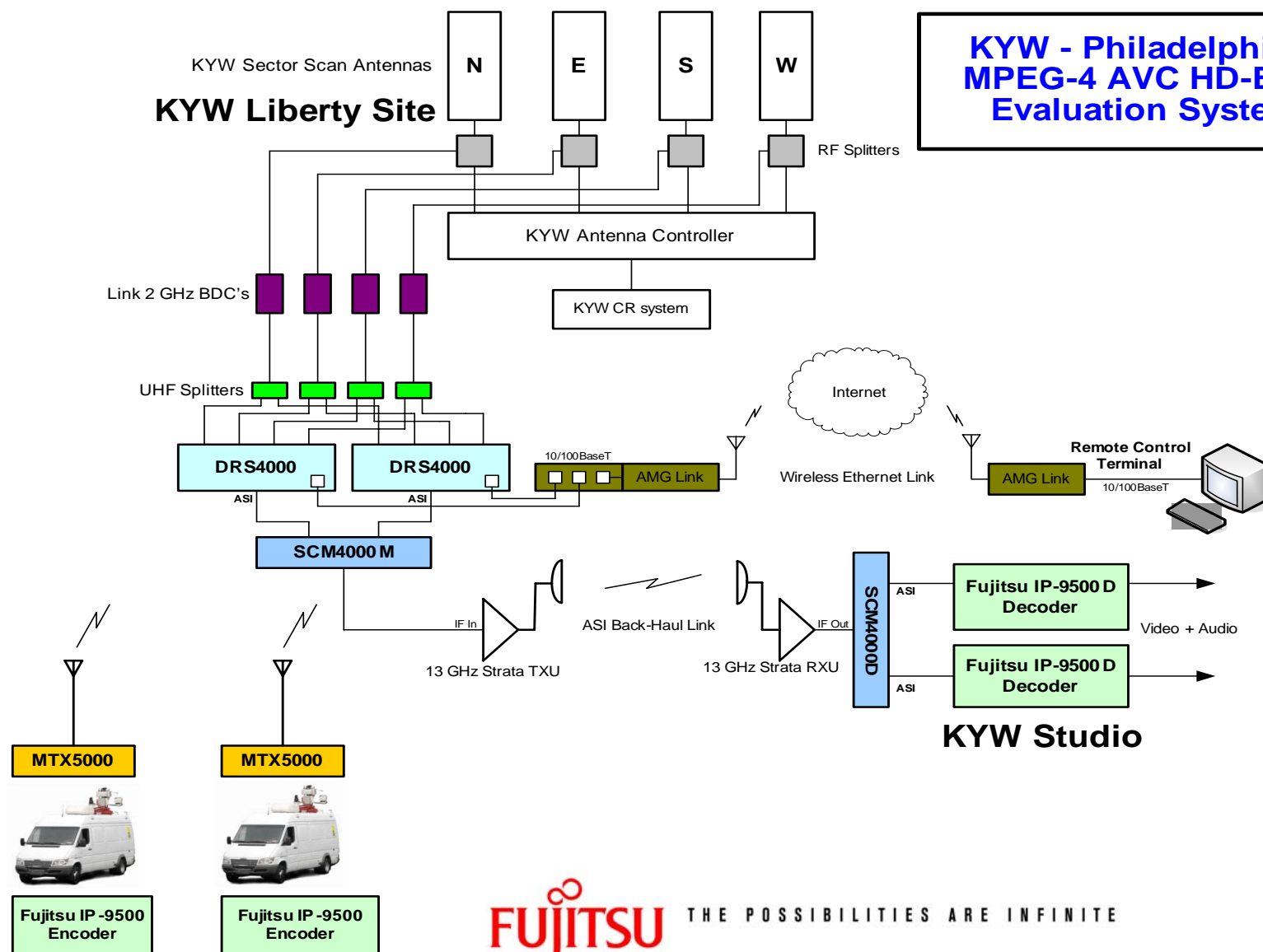
*Assumes ~300Kbps buffer between Modulator ASI input and Encoder ASI output

■ Presets 9 and 10 illustrate use of single high bit-rate video feed but are better suited to multiplexing of multiple lower bit-rate streams and/or IP data traffic before the DVB-T modulator

KYW HD-ENG Field Trial System



**KYW - Philadelphia
MPEG-4 AVC HD-ENG
Evaluation System**



M. Wheeler 7/16/2008

KYW HD-ENG Field Trial Demo Workflow

■ Field Production

- Camera Original
 - Recorded on Sony XDCAM HD Pro-Disc @ 35Mbps (HQ mode)
- Receiver Original
 - Encoded by Fujitsu IP-9500 MPEG-4 AVC Encoder
 - Backhauled by MRC MXT5000 XMTR & DRS4000 RCVR
 - Decoded by Fujitsu IP-9500D MPEG-4 AVC Decoder
 - Recorded on Sony XDCAM HD Pro-Disc @ 35Mbps

■ Post Production

- Server-based edit of Master
 - Originals recorded into GV K2 Server @ 50Mbps I Frame
 - Master edited/rendered on GV K2 Server @ 50Mbps I Frame
 - Master recorded on Sony XDCAM HD Pro-Disc @ 35Mbps

■ Camera Original processed through 4 codecs

■ Receiver Original processed through 5 codecs

■ Roll the demo!

KYW HD-ENG Field Trial Results for 8MHz Channel

XMTR Location	Distance to RCVR	XMTR Antenna	XMTR Site Type	Constellation	FEC	GI	Modulator Data Rate (Mbps)	Encoder TS Bit Rate (Mbps)	Video Bit Rate (Mbps)	Audio Bit Rate (Kbps)	Video Quality
Kimmel Cntr	0.4mi	Omni	No LoS	QPSK	2/3	1/8	7.37	7.0	6.2	64	No Artifacts
Kimmel Cntr	0.4mi	Omni	No LoS	QPSK	5/6	1/16	9.76	9.4	8.6	64	No Artifacts
Kimmel Cntr	0.4mi	Omni	No LoS	16QAM	1/2	1/8	11.06	10.7	9.9	64	No Artifacts
Kimmel Cntr	0.4mi	Omni	No LoS	16QAM	2/3	1/16	15.61	15.3	14.4	64	No Artifacts
Kimmel Cntr	0.4mi	Omni	No LoS	16QAM	5/6	1/16	19.52	19.2	18.2	64	MB, FF

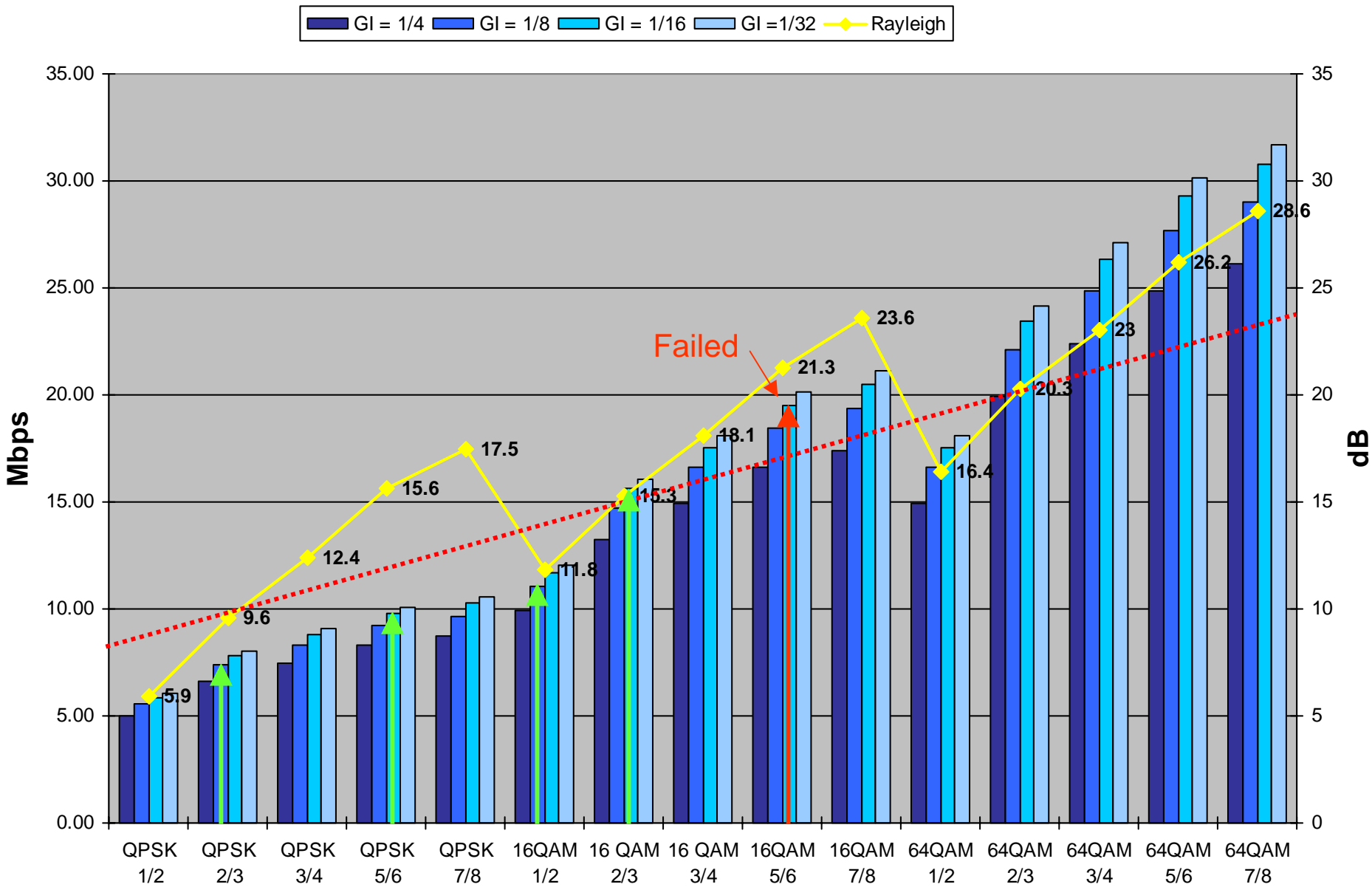
Video source is 1080i/59.94Hz format, 1440 horizontal resolution; Video encoding is MPEG-4 AVC HP/L4

Audio source is one AES Stereo Pair; Audio encoding is MPEG-2 AAC

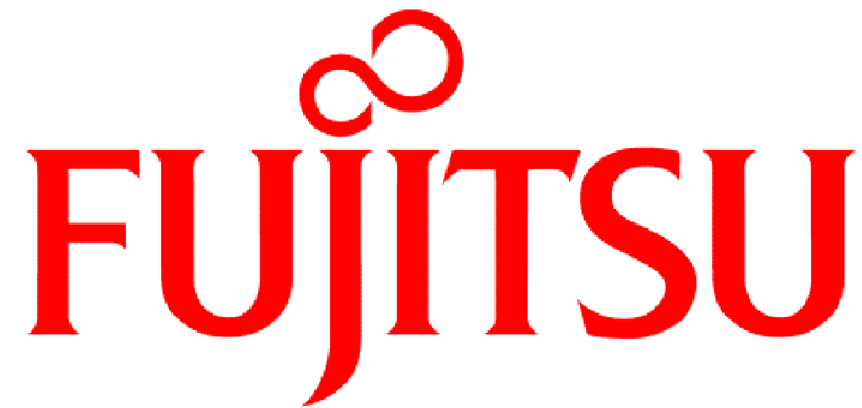
MB: Macro Blocking

FF: Freeze Frame

Rayleigh Channel Mapping of KYW Field Trial Operating Points



- Many thanks to the following for their expertise, effort and assistance in conducting the field trials
 - MRC
 - Mike Wheeler
 - Vance D'Arcangelo
 - Bob Morrisette
 - KYW
 - George Gammond
 - Fujitsu
 - Rich Harvey
- Special thanks to Rich Paleski of KYW and Rich Miller of MRC for their many years of ENG expertise which greatly assisted in organizing and guiding the trials
 - Final thanks to Russell Booth of KYW who made editing the Master so easy!



THE POSSIBILITIES ARE INFINITE