

Jointwave H.264 Encoder Series IP Cores Benchmark

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1. Introduction

Since all the Jointwave H.264 encoder IP cores share the same algorithm, the benchmark results below are the same for all Main Profile encoders, from E600 to E670.

Due to the slow running speed of verilog simulation model, the benchmark results are gathered from corresponding C language model, the output of C language model is bit-to-bit identical to verilog model.

2. Terminology

JM86	JVT(Joint Video Team of ISO/IEC MPEG and ITU-T VCEG) Joint Model Reference Encoder http://iphone.hhi.de/suehring/tml/download/old_jm/jm86.zip
Jointwave C-Model	Jointwave H.264 encoder C language model
NAL	ITU-T H.264 Annex B Byte stream format
JW	Jointwave C-Model
PSNR	Peak signal-to-noise ratio

3. Test Method and Setting

For each YUV 4:2:0 sequence, we use JM86 as a reference to compare encoding efficiency. The configuration parameters of JM86 are set to the same as Jointwave C-model if possible. The first and only the first frame is encoded as an I-frame, all of other frames are encoded as P-frames or B-frames. The size of each encoded NAL byte streams are measured in bytes.

The size of encoded NAL stream file in bytes and luma PSNR of both encoders are compared in a series of tables.

Following the tables, there are “stream bytes” and “Luma PSNR” comparative charts for all sequences.

For each sequence in a specified QP, the NAL stream bytes outputted by JM86 is used as a base, if the NAL stream bytes outputted by Jointwave C-Model is 100.8% of the base, then 0.8 is used as the result value of the sequence in the charts.

For each sequence in a specified QP, the difference of PSNR is used as the result value, and calculated by subtracting the PSNR of JM86 from the PSNR of Jointwave C-Model. e.g. if PSNR of JM86 is 40.34 and PSNR of Jointwave C model is 40.28, the value $40.28 - 40.34 = -0.06$ is used as the result in the charts.

For each sequence, 5 QP in the most useful range 18~34 were tested: **18, 22, 26, 30, 34**.

Two GOP patterns were tested: **IBPBP...** and **IPP...**

Configuration parameters of JM86

SI i ceMode	= 0
UseHadamard	= 1
NumberReferenceFrames	= 1
I nterSearch16x16	= 1
I nterSearch16x8	= 1
I nterSearch8x16	= 1
I nterSearch8x8	= 1
I nterSearch8x4	= 0
I nterSearch4x8	= 0
I nterSearch4x4	= 0
UseFME	= 0
SearchRange	= 16
Wei ghtedPredi cti on	= 0
Wei ghtedBI Predi cti on	= 0
Di rectModeType	= 1
Symbol Mode	= 1
OutFi l eMode	= 0
Pi cI nterI ace	= 0
MbI nterI ace	= 0
LoopFi l terDi sabl e	= 0

RDOptimization	= 0
QPFIRSTFrame	= QP
QPREMAININGFrame	= QP
QPBPicture	= QP + 2
ChromaQPOffset	= 2

4. YUV 4:2:0 Sequences for Test

The CIF (352x288) progressive sequences listed in table 4-1 are “industry standard” sequences used by numerous video codec developers .

The VGA (640x480) progressive sequences listed in table 4-1 are created by us base on some 1920x1080p sequences downloaded from:

ftp://ftp.ldv.e-technik.tu-muenchen.de/pub/test_sequences/.

To create a 640x480 sequence, the central 1440x1080 part of a 1920x1080 sequence is cropped and downsized to 640x480 by ratio 1/2.25 and by bicubic algorithm.

The number of tested frames of *GOP IPP* is NumberOfTestedFrames in table 4-1, the number of tested frames of *GOP IBPBP* is derived by:

$$\text{NumberOfTestedFrames} - 1$$

Sequence Name	Resolution	NumberOfTestedFrames
akiyo	352x288	300
bridge-close	352x288	300
coastguard	352x288	300
football-90	352x288	90
foreman	352x288	300
hall_monitor	352x288	300
highway	352x288	300
husky	352x288	300
mobile	352x288	300
mother_daughter	352x288	300
news	352x288	300
paris	352x288	300
salesman	352x288	300
students	352x288	300
tempete	352x288	300
pedestrian_area	640x480	250
riverbed	640x480	250
sunflower	640x480	250
tractor	640x480	250

Table 4-1. Test Sequences

5. *IBPBP* Test Results

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	18	45.31	45.27	413356	385360
bridge-close	352x288	18	41.89	41.83	3996263	3613320
coastguard	352x288	18	41.77	41.71	4353258	3909414
football-90	352x288	18	43.38	43.14	1134265	1050818
foreman	352x288	18	42.51	42.51	2393126	2269353
hall_monitor	352x288	18	42.77	42.70	2527104	2297988
highway	352x288	18	42.51	42.44	2505645	2323545
husky	352x288	18	40.92	40.67	9290758	8744696
mobile	352x288	18	41.51	41.54	5833593	5366192
mother_daughter	352x288	18	43.70	43.69	980503	900715
news	352x288	18	44.13	44.08	886040	803550
paris	352x288	18	42.77	42.79	1807492	1703784
salesman	352x288	18	41.91	41.89	1446175	1433409
students	352x288	18	43.37	43.39	929205	869723
tempete	352x288	18	42.02	42.02	4279989	3977051
pedestrian-area	640x480	18	42.17	42.10	5651823	5311244
riverbed	640x480	18	41.67	41.05	19129553	18547848
sunflower	640x480	18	43.28	43.27	3332736	3247853
tractor	640x480	18	41.97	41.87	11537028	10634106

Table 5-1 GOP *IBPBP* Q18 test result

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	22	43.20	43.14	219120	205350
bridge-close	352x288	22	38.94	38.97	1534722	1347228
coastguard	352x288	22	38.60	38.61	2635411	2378790
football-90	352x288	22	40.74	40.50	734094	680681
foreman	352x288	22	39.85	39.81	1259931	1219439
hall_monitor	352x288	22	40.41	40.41	944065	858338
highway	352x288	22	40.67	40.56	873032	798369
husky	352x288	22	37.28	37.08	6917693	6453843
mobile	352x288	22	38.11	38.20	3663084	3368516
mother_daughter	352x288	22	41.49	41.46	478408	449238
news	352x288	22	41.85	41.81	533487	487855
paris	352x288	22	39.87	39.91	1137914	1064941
salesman	352x288	22	39.13	39.04	581378	581938
students	352x288	22	40.71	40.68	490343	463084
tempete	352x288	22	38.82	38.85	2648085	2463897
pedestrian-area	640x480	22	40.07	39.96	2768281	2612288
riverbed	640x480	22	38.56	38.07	12347299	12044498
sunflower	640x480	22	41.31	41.20	1622394	1569052
tractor	640x480	22	39.16	39.11	6178837	5676844

Table 5-2 GOP *IBPBP* Q22 test result

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	26	40.83	40.76	111923	106258
bridge-close	352x288	26	36.30	36.48	596534	570279
coastguard	352x288	26	35.44	35.51	1424991	1334994
football-90	352x288	26	38.04	37.82	455506	429136
foreman	352x288	26	37.15	37.07	636201	636271
hall_monitor	352x288	26	38.32	38.40	350977	330157
highway	352x288	26	38.89	38.78	329864	319949
husky	352x288	26	33.65	33.55	4817149	4477452
mobile	352x288	26	34.58	34.82	2043143	1953414
mother_daughter	352x288	26	39.00	38.83	245636	232355
news	352x288	26	39.26	39.13	315199	290649
paris	352x288	26	36.66	36.70	688943	651861
salesman	352x288	26	36.76	36.63	239929	239921
students	352x288	26	37.85	37.70	249634	237652
tempete	352x288	26	35.45	35.60	1432196	1387597
pedestrian-area	640x480	26	37.99	37.82	1504849	1419820
riverbed	640x480	26	35.71	35.37	7830941	7644096
sunflower	640x480	26	38.94	38.78	794084	793185
tractor	640x480	26	36.45	36.45	3038321	2892217

Table 5-3 GOP **IBPBP** Q26 test result

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	30	38.30	38.19	60290	56552
bridge-close	352x288	30	33.84	33.91	271785	264406
coastguard	352x288	30	32.66	32.69	707378	690363
football-90	352x288	30	35.42	35.26	275947	263298
foreman	352x288	30	34.68	34.48	332401	335797
hall_monitor	352x288	30	36.25	36.16	159864	151122
highway	352x288	30	37.08	36.90	151121	149227
husky	352x288	30	30.10	30.12	3046820	2847096
mobile	352x288	30	31.29	31.51	1013368	1016188
mother_daughter	352x288	30	36.49	36.29	132405	125040
news	352x288	30	36.59	36.41	187192	174477
paris	352x288	30	33.61	33.59	391389	377932
salesman	352x288	30	34.53	34.34	121755	115341
students	352x288	30	35.16	34.98	130240	123507
tempete	352x288	30	32.40	32.51	698259	703934
pedestrian-area	640x480	30	35.88	35.68	851197	819277
riverbed	640x480	30	33.02	32.80	4736127	4660782
sunflower	640x480	30	36.48	36.31	410630	413313
tractor	640x480	30	33.97	33.87	1580991	1509292

Table 5-4 GOP **IBPBP** Q30 test result

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	34	35.79	35.67	33966	30987
bridge-close	352x288	34	31.65	31.60	115746	113154
coastguard	352x288	34	30.21	30.07	341159	337416
football-90	352x288	34	32.93	32.84	162120	160276
foreman	352x288	34	32.32	32.04	186463	190783
hall_monitor	352x288	34	33.88	33.77	81634	75550
highway	352x288	34	35.31	34.87	73274	73103
husky	352x288	34	26.78	26.96	1734294	1681454
mobile	352x288	34	28.43	28.43	484594	492587
mother_daughter	352x288	34	33.89	33.70	72674	69485
news	352x288	34	33.93	33.55	110883	104925
paris	352x288	34	30.74	30.67	214885	211033
salesman	352x288	34	32.16	31.98	66462	64007
students	352x288	34	32.61	32.42	69773	65971
tempete	352x288	34	29.72	29.68	339345	345973
pedestrian-area	640x480	34	33.74	33.52	489342	493665
riverbed	640x480	34	30.39	30.45	2681786	2742358
sunflower	640x480	34	33.71	33.61	216625	233906
tractor	640x480	34	31.47	31.41	834823	825240

Table 5-5 GOP IBPBP Q34 test result

IBPBP charts:

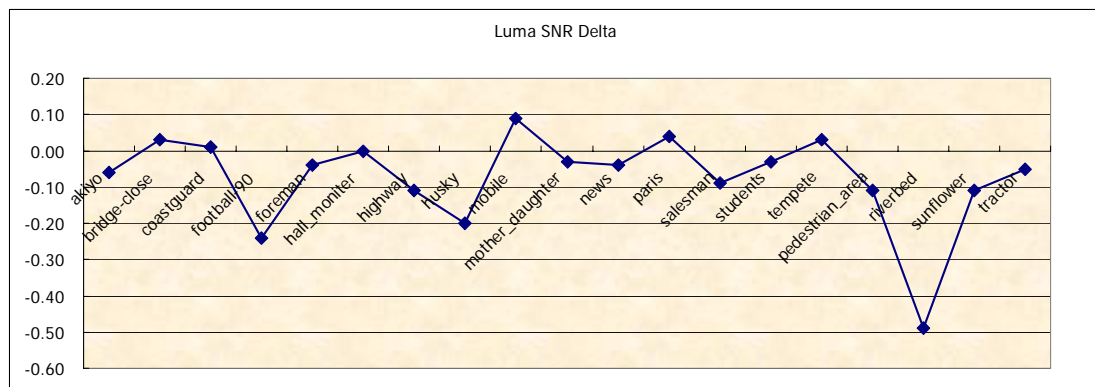
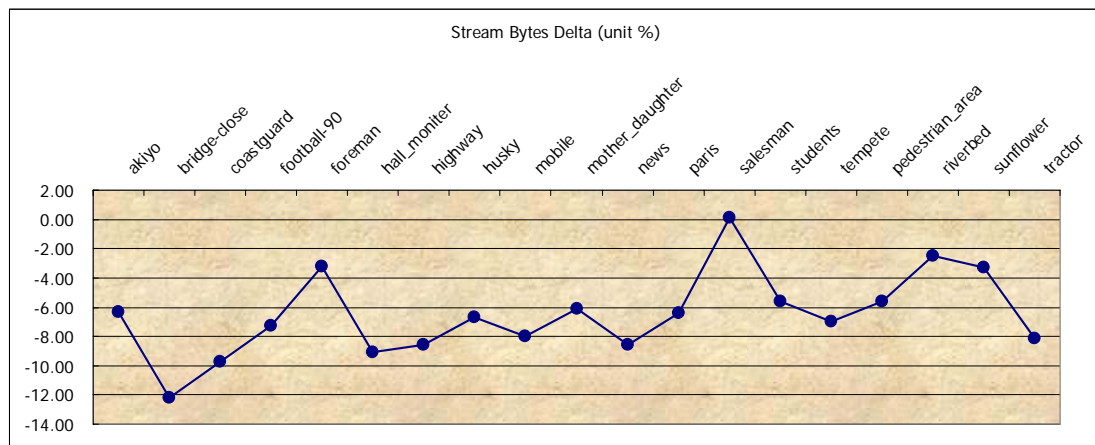


Chart 5-1 All Sequences, QP22

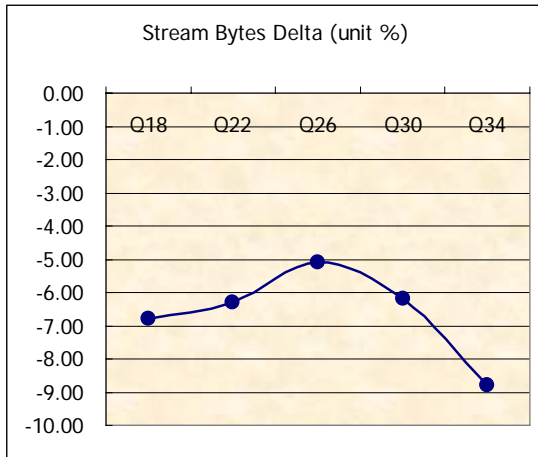
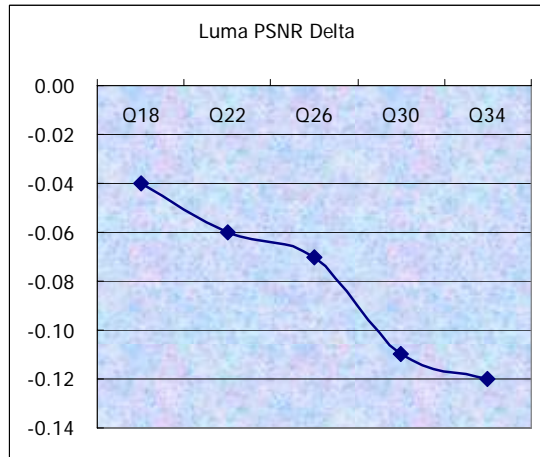


Chart 5- 2. akiyo



352x288 IBPBP

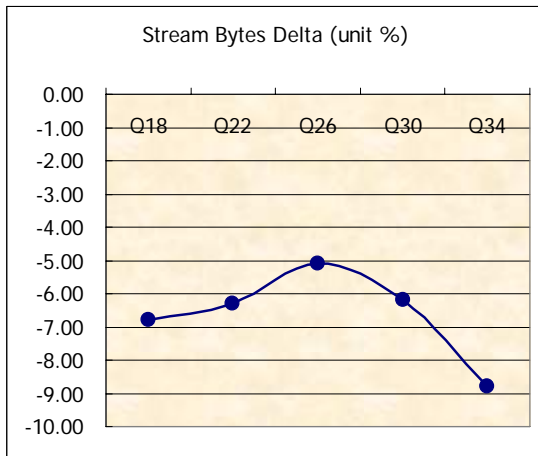
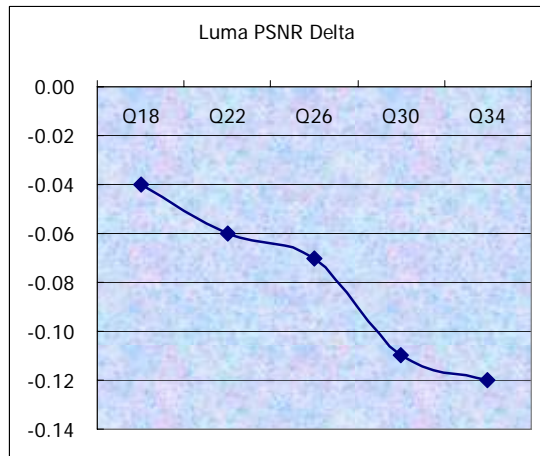


Chart 5- 3. bridge-close



352x288 IBPBP

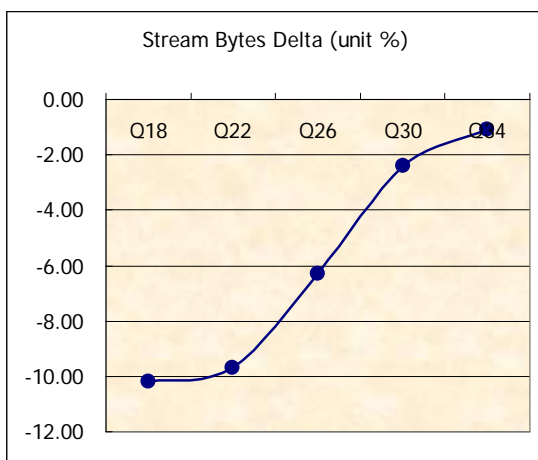
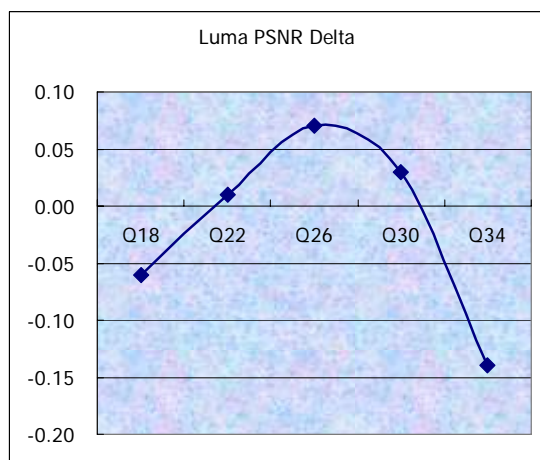


Chart 5- 4. coastguard



352x288 IBPBP

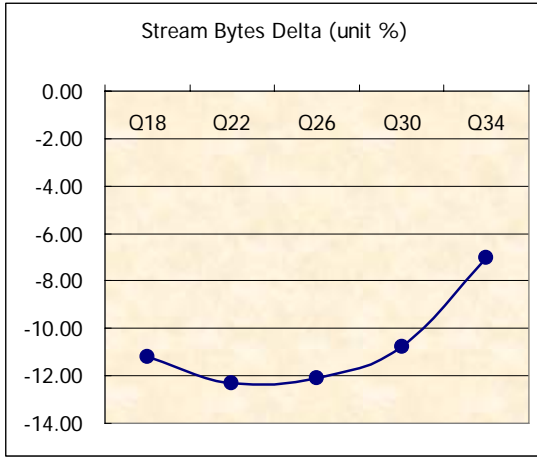
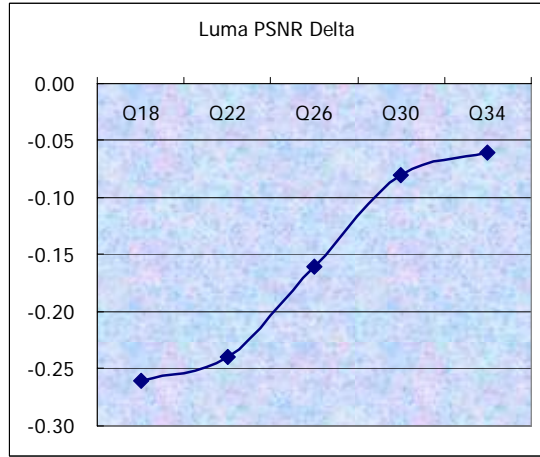


Chart 5- 5. football-90



352x288 IBPBP

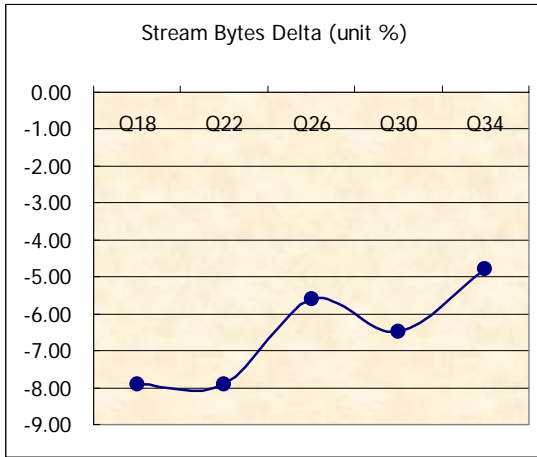
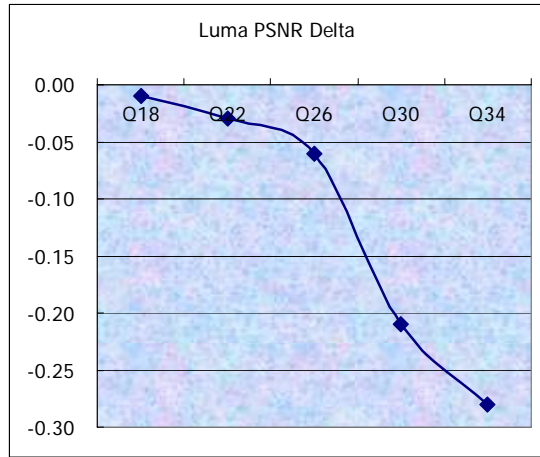


Chart 5- 6. foreman



352x288 IBPBP

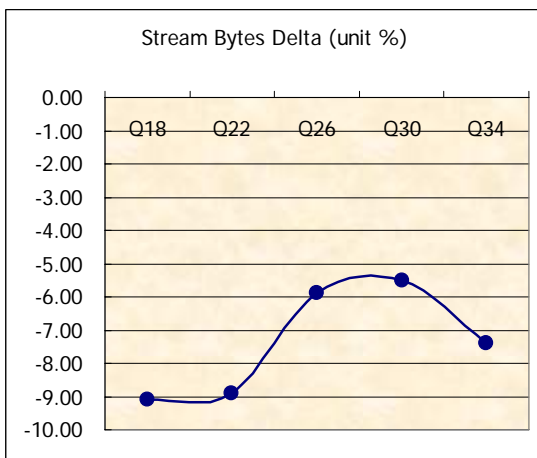
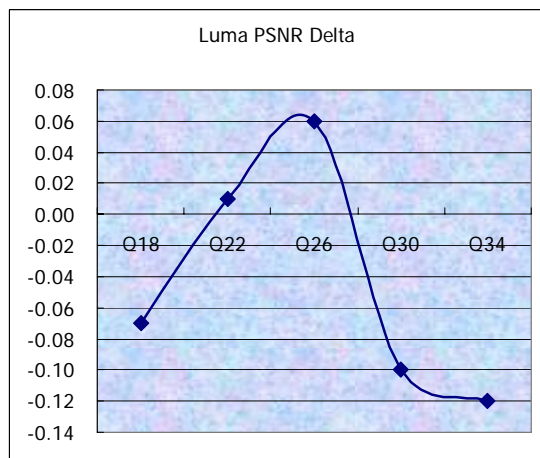


Chart 5- 7. hall_monitor



352x288 IBPBP

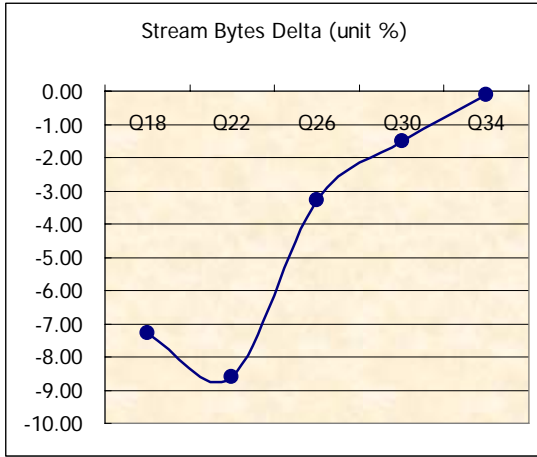
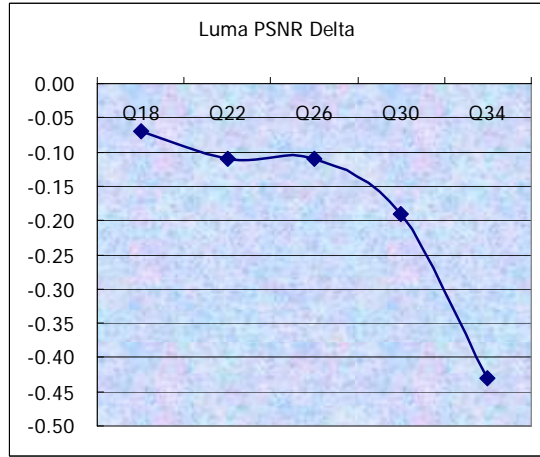


Chart 5- 8. highway



352x288 IBPBP

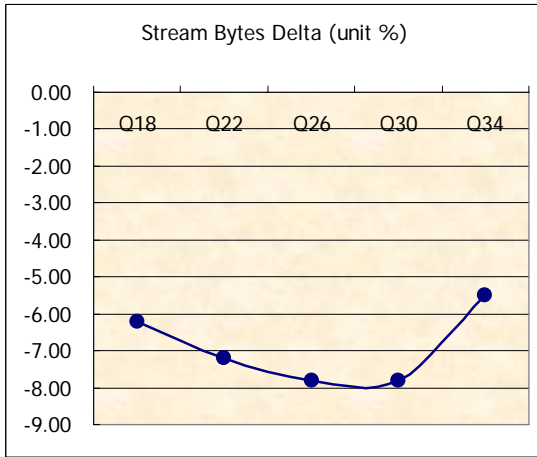
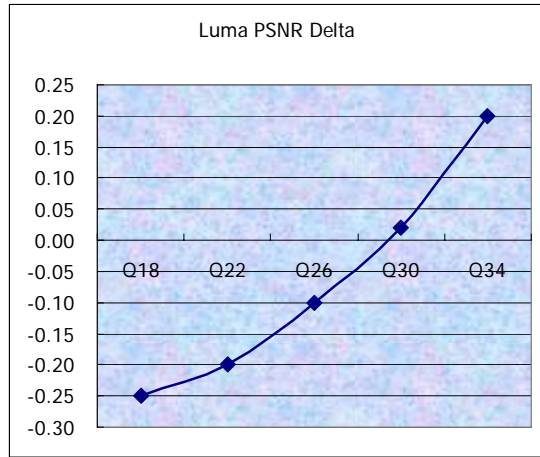


Chart 5- 9. husky



352x288 IBPBP

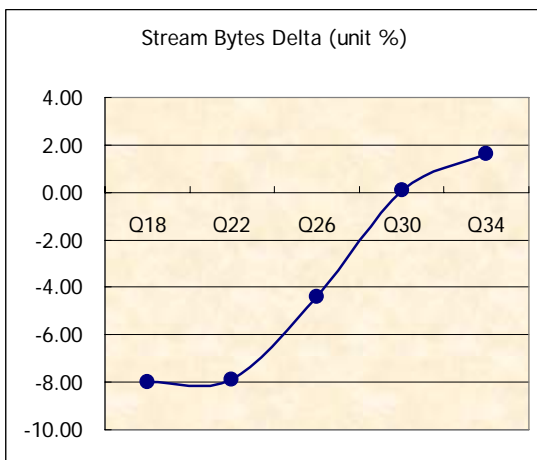
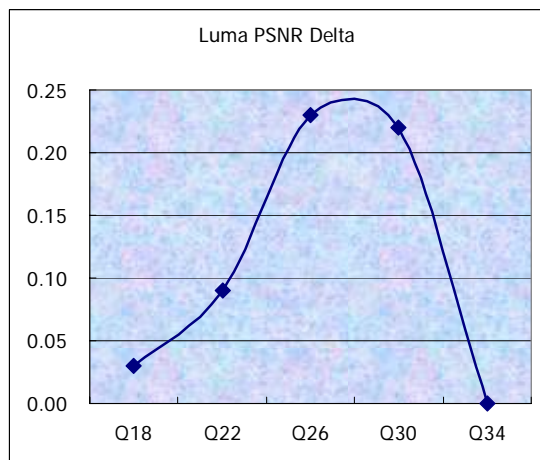


Chart 5-10. mobile



352x288 IBPBP

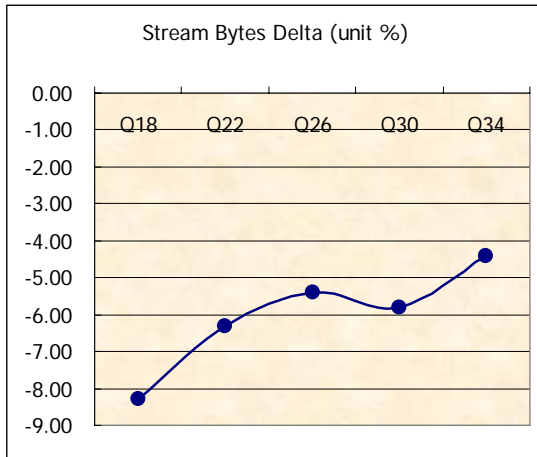
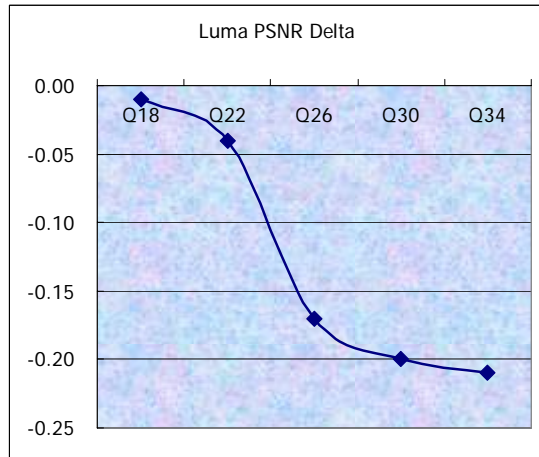


Chart 5-11. mother_daughter



352x288 IBPBP

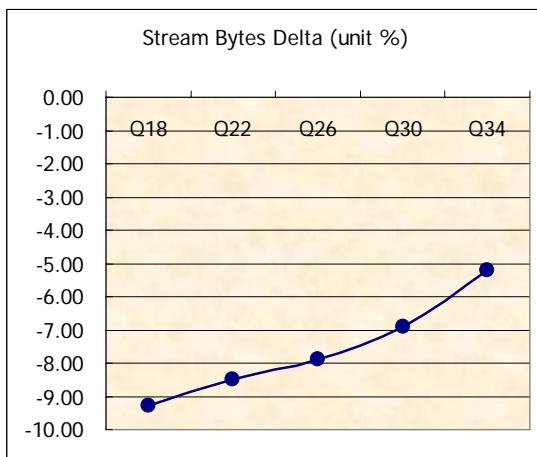
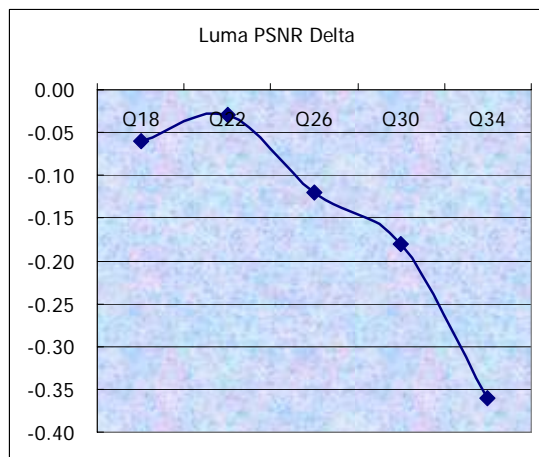


Chart 5-12. news



352x288 IBPBP

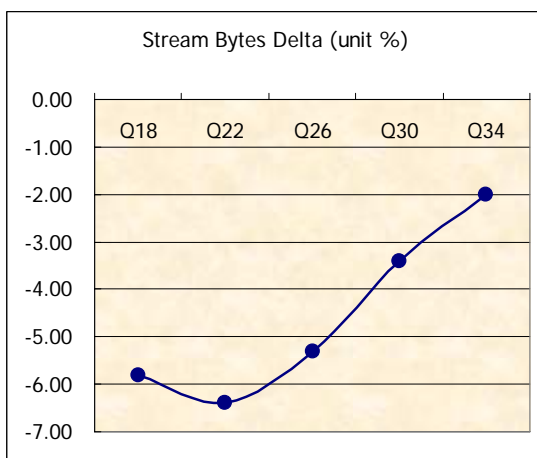
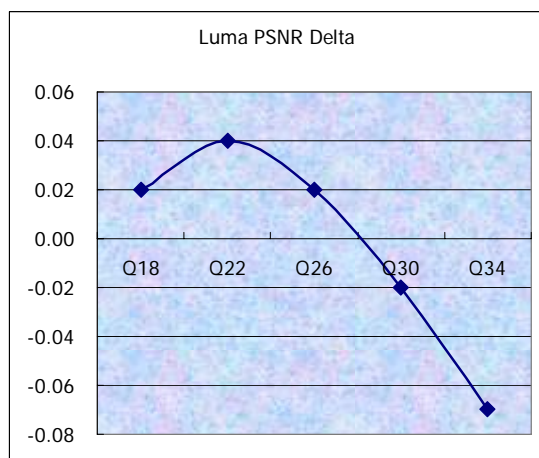


Chart 5-13. paris



352x288 IBPBP

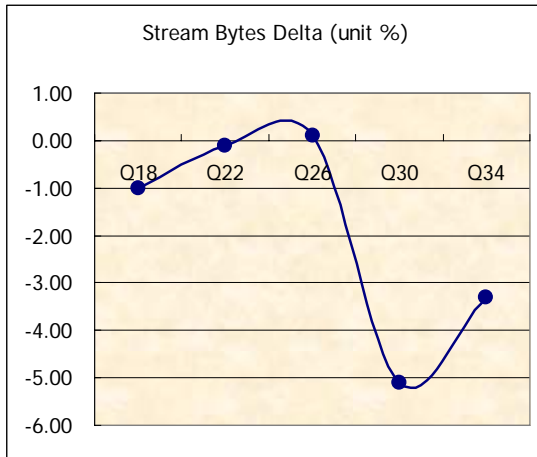
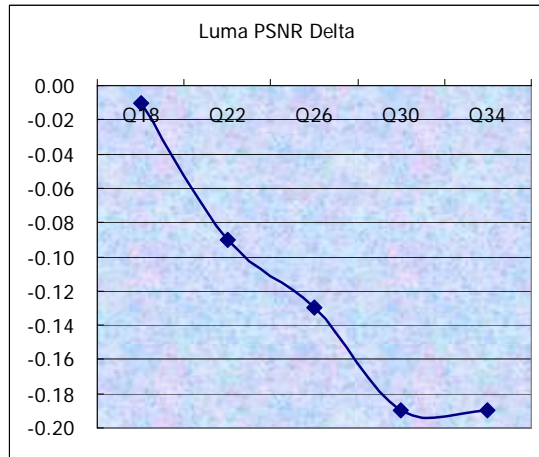


Chart 5-14. salesman



352x288 IBPBP

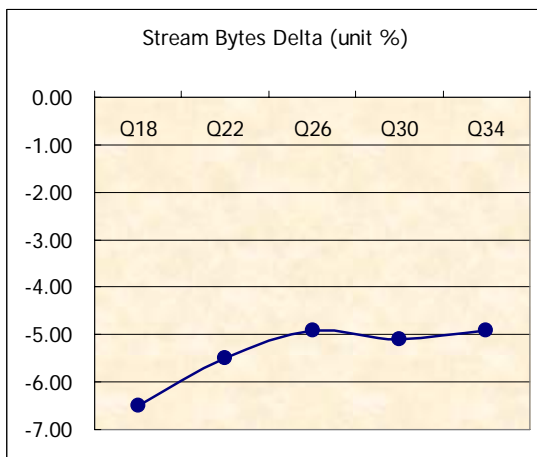
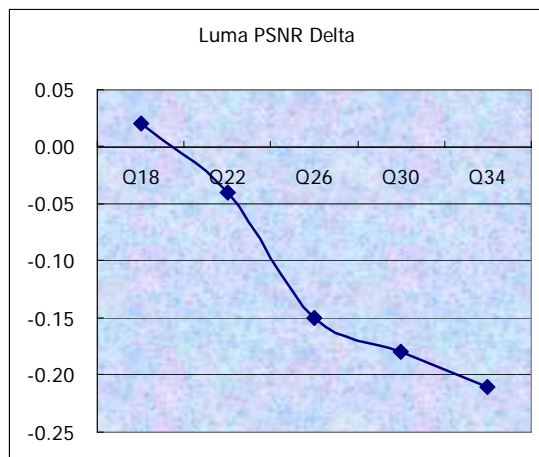


Chart 5-15. students



352x288 IBPBP

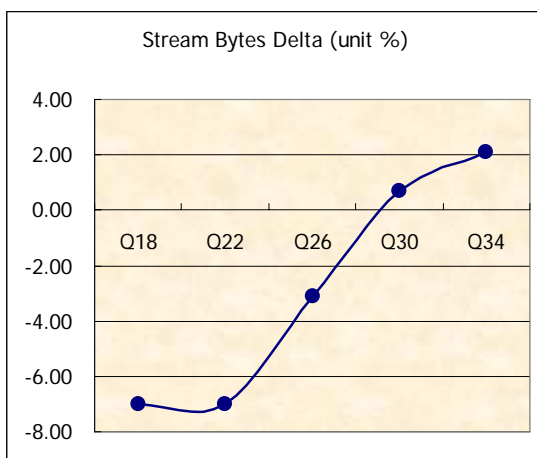
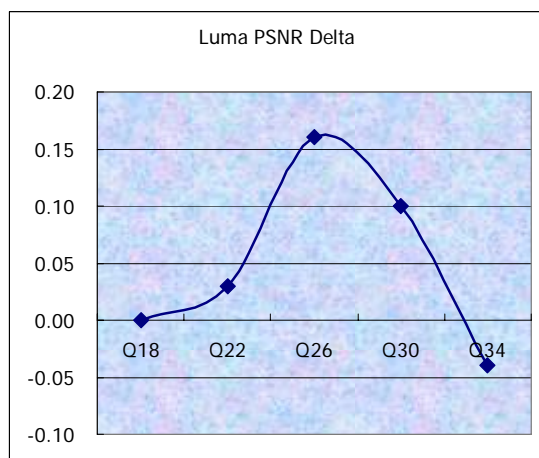


Chart 5-16. tempete



352x288 IBPBP

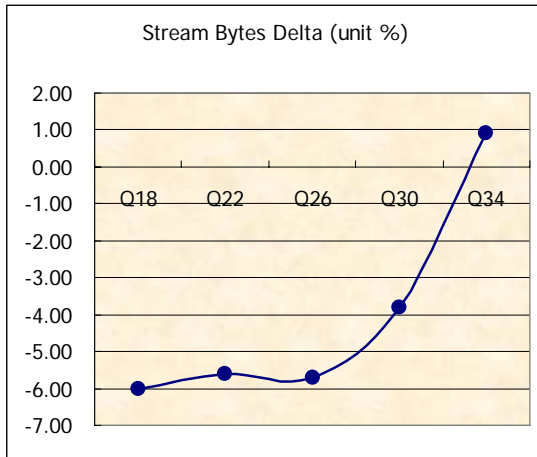
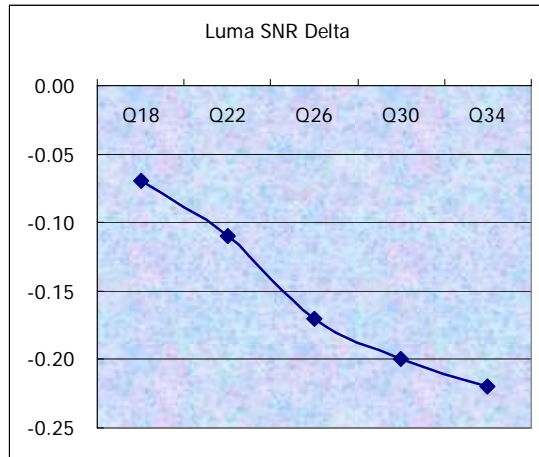


Chart 5-17. pedestrian_area



640x480 IBPBP

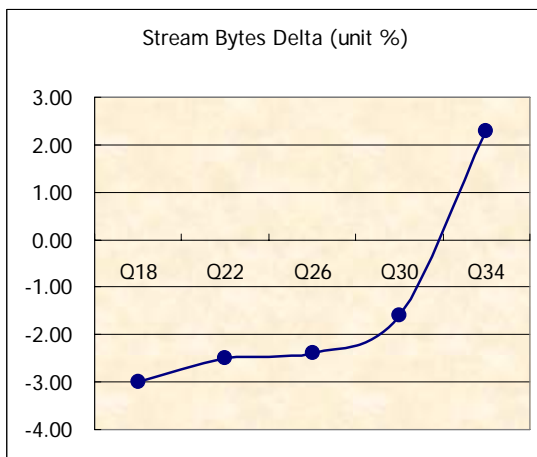
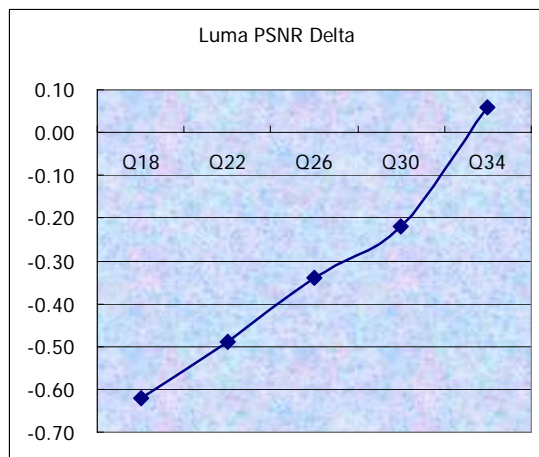


Chart 5-18. riverbed



640x480 IBPBP

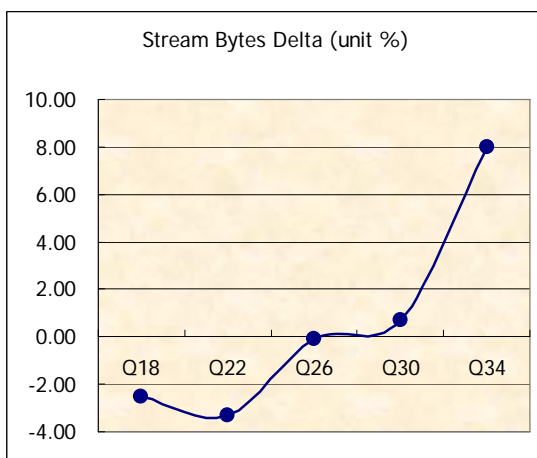
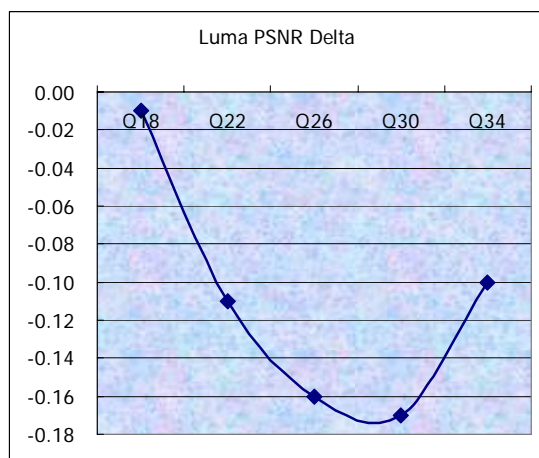


Chart 5-19. sunflower



640x480 IBPBP

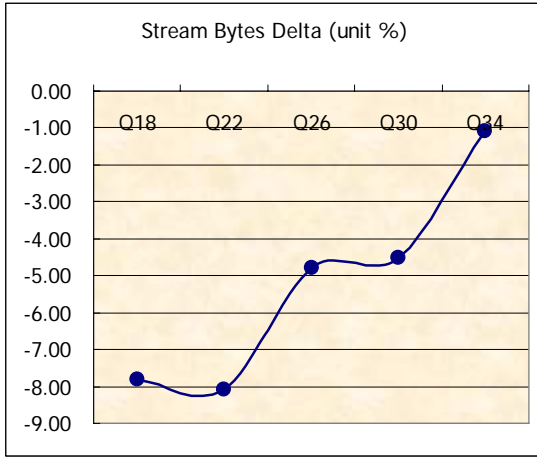
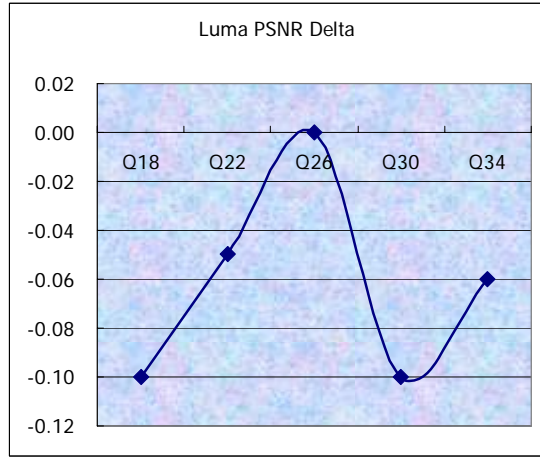


Chart 5-20.

tractor



640x480

IBPBP

6. *IPP* Test Results

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	18	45.47	45.45	479969	492137
bridge-close	352x288	18	42.77	42.68	4742827	4660807
coastguard	352x288	18	42.46	42.37	4589663	4600609
football-90	352x288	18	43.94	43.69	1176569	1167484
foreman	352x288	18	43.16	43.08	2781700	2817523
hall_monitor	352x288	18	43.51	43.35	3070601	3001322
highway	352x288	18	43.08	43.03	3030075	2998390
husky	352x288	18	41.77	41.53	9539816	9360238
mobile	352x288	18	42.26	42.21	6727612	6754289
mother_daughter	352x288	18	44.13	44.05	1217875	1227834
news	352x288	18	44.28	44.27	929011	971670
paris	352x288	18	42.98	43.09	1938783	1996508
salesman	352x288	18	42.54	42.47	2371647	2395504
students	352x288	18	43.54	43.60	1079213	1109505
tempete	352x288	18	42.76	42.66	4801491	4833580
pedestrian-area	640x480	18	42.75	42.64	6621257	6711773
riverbed	640x480	18	42.57	41.82	21139741	20486829
sunflower	640x480	18	43.72	43.66	4232529	4283909
tractor	640x480	18	42.66	42.55	12596240	12649464

Table 6-1 GOP *IPP* Q18 test result

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	22	43.22	43.26	254778	263739
bridge-close	352x288	22	39.49	39.47	1952120	1852813
coastguard	352x288	22	39.24	39.18	2894289	2913366
football-90	352x288	22	41.22	41.02	759558	756231
foreman	352x288	22	40.31	40.26	1504888	1550855
hall_monitor	352x288	22	40.89	40.85	1167417	1163938
highway	352x288	22	41.00	40.96	1077410	1044631
husky	352x288	22	38.22	38.02	7225479	7084838
mobile	352x288	22	38.92	38.88	4509706	4532226
mother_daughter	352x288	22	41.66	41.66	580937	597140
news	352x288	22	41.90	41.94	556170	579275
paris	352x288	22	39.98	40.18	1224450	1257415
salesman	352x288	22	39.51	39.52	860309	874625
students	352x288	22	40.74	40.81	571883	590937
tempete	352x288	22	39.58	39.50	3126257	3154180
pedestrian-area	640x480	22	40.35	40.30	3070804	3183369
riverbed	640x480	22	39.39	38.83	13785022	13520003
sunflower	640x480	22	41.60	41.54	2100391	2130235
tractor	640x480	22	39.87	39.77	6951816	7023053

Table 6-2 GOP *IPP* Q22 test result

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	26	40.74	40.81	128800	132638
bridge-close	352x288	26	36.60	36.78	732833	727003
coastguard	352x288	26	35.93	35.86	1630225	1640350
football-90	352x288	26	38.39	38.18	463110	462860
foreman	352x288	26	37.41	37.34	747719	779708
hall_monitor	352x288	26	38.68	38.66	442109	422285
highway	352x288	26	39.11	39.06	385357	394497
husky	352x288	26	34.47	34.29	5062781	4946342
mobile	352x288	26	35.31	35.26	2707943	2722375
mother_daughter	352x288	26	38.92	38.91	287896	295849
news	352x288	26	39.22	39.19	322147	334502
paris	352x288	26	36.78	36.90	753280	769320
salesman	352x288	26	36.87	36.88	291163	300872
students	352x288	26	37.75	37.76	287011	296285
tempete	352x288	26	36.15	36.06	1799421	1821146
pedestrian-area	640x480	26	38.14	38.04	1613247	1649196
riverbed	640x480	26	36.48	36.00	8687300	8511102
sunflower	640x480	26	39.10	39.03	1038750	1058859
tractor	640x480	26	37.03	36.89	3454512	3496100

Table 6-3 GOP IPP Q26 test result

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	30	38.12	38.19	67442	69180
bridge-close	352x288	30	33.99	34.09	343604	347426
coastguard	352x288	30	32.98	32.92	847301	859217
football-90	352x288	30	35.85	35.65	281981	284027
foreman	352x288	30	34.80	34.70	374656	396572
hall_monitor	352x288	30	36.35	36.34	187026	187551
highway	352x288	30	37.23	37.12	175231	181586
husky	352x288	30	30.97	30.80	3312398	3222441
mobile	352x288	30	31.84	31.80	1467233	1479857
mother_daughter	352x288	30	36.31	36.32	150298	155763
news	352x288	30	36.52	36.46	189920	197780
paris	352x288	30	33.66	33.73	441671	452169
salesman	352x288	30	34.47	34.46	133888	138591
students	352x288	30	35.00	35.00	146260	150561
tempete	352x288	30	32.90	32.81	933850	955306
pedestrian-area	640x480	30	35.98	35.88	904487	936804
riverbed	640x480	30	33.88	33.51	5380545	5316857
sunflower	640x480	30	36.51	36.54	527133	563212
tractor	640x480	30	34.34	34.23	1756323	1821487

Table 6-4 GOP IPP Q30 test result

Sequence	Resolution	QP	JM86 PSNR	JW PSNR	JM86 size	JW size
akiyo	352x288	34	35.57	35.68	37027	37183
bridge-close	352x288	34	31.59	31.65	139705	147186
coastguard	352x288	34	30.24	30.20	396913	416082
football-90	352x288	34	33.51	33.23	168200	171930
foreman	352x288	34	32.36	32.24	196952	215984
hall_monitor	352x288	34	33.84	33.87	93493	91329
highway	352x288	34	35.35	35.04	81473	85686
husky	352x288	34	27.72	27.57	2016155	1955890
mobile	352x288	34	28.58	28.59	704649	726106
mother_daughter	352x288	34	33.72	33.72	82088	85444
news	352x288	34	33.80	33.59	113248	117142
paris	352x288	34	30.74	30.77	243772	251429
salesman	352x288	34	32.05	32.02	72144	74730
students	352x288	34	32.42	32.41	76826	79036
tempete	352x288	34	29.89	29.85	445642	466069
pedestrian-area	640x480	34	33.83	33.66	518387	552232
riverbed	640x480	34	31.45	31.19	3189550	3198489
sunflower	640x480	34	33.69	33.82	271022	316577
tractor	640x480	34	31.78	31.70	922182	981745

Table 6-5 GOP IPP Q34 test result

IPP charts:

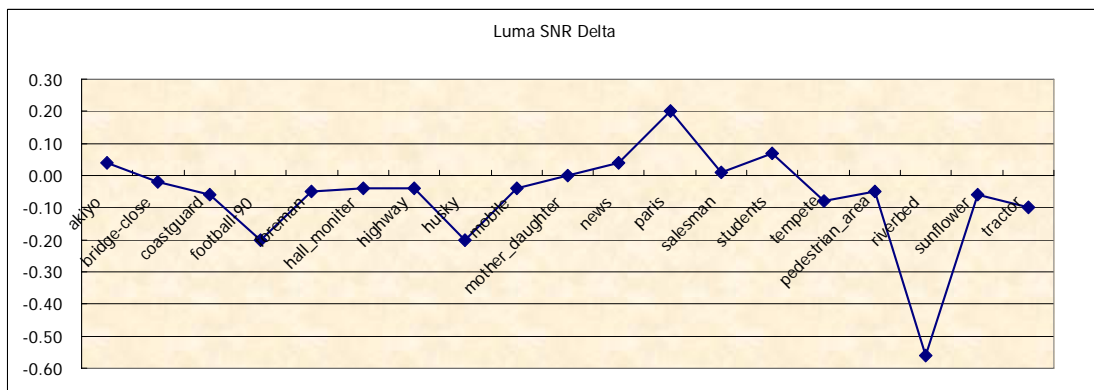
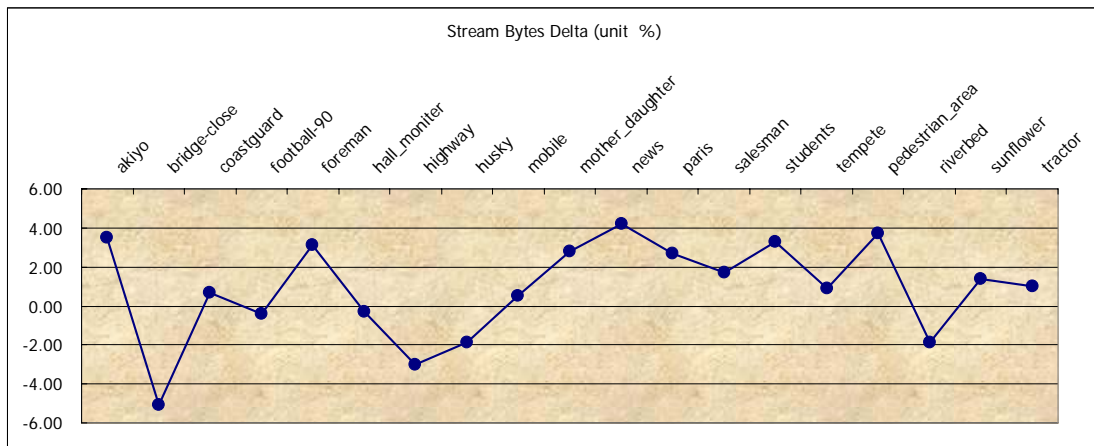


Chart 6-1. All Sequences, QP22

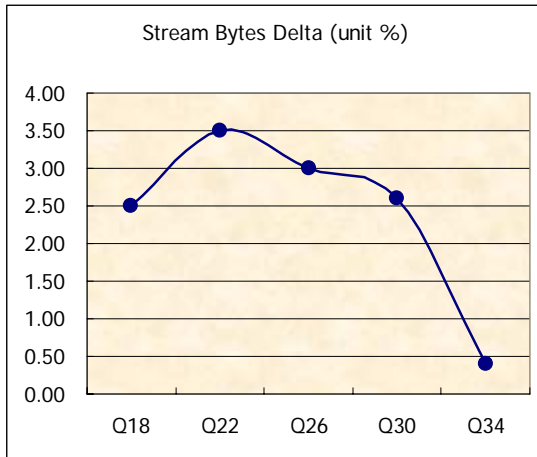
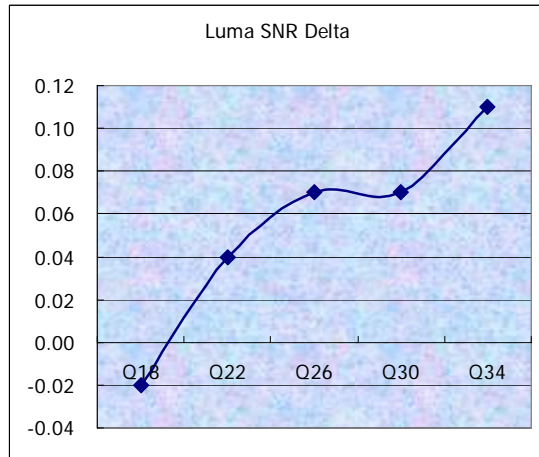


Chart 6- 2. akiyo



352x288 IPP

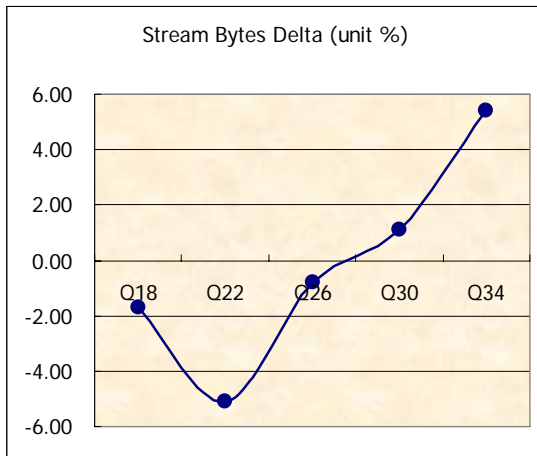
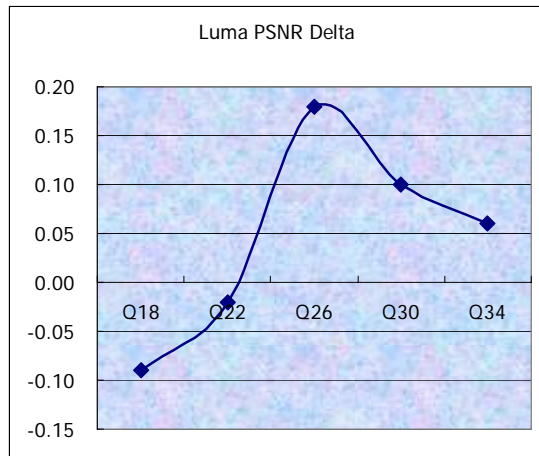


Chart 6- 3. bridge-close



352x288 IPP

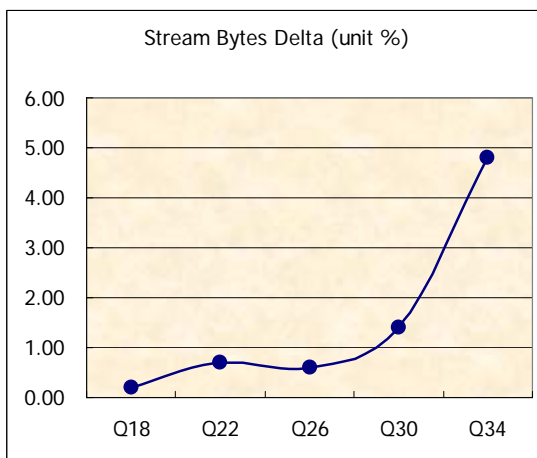
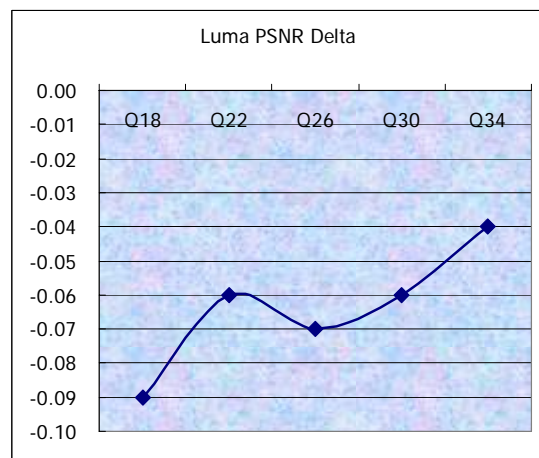


Chart 6- 4. coastguard



352x288 IPP

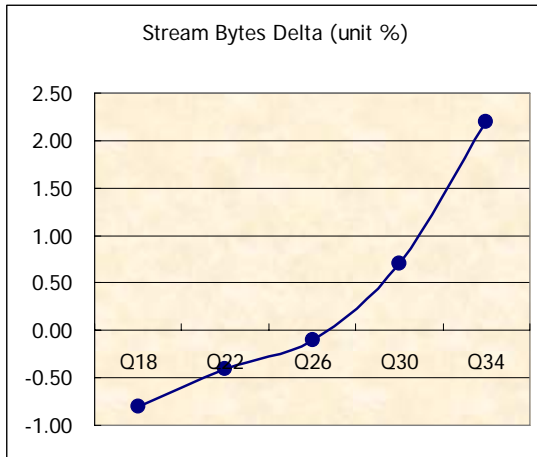
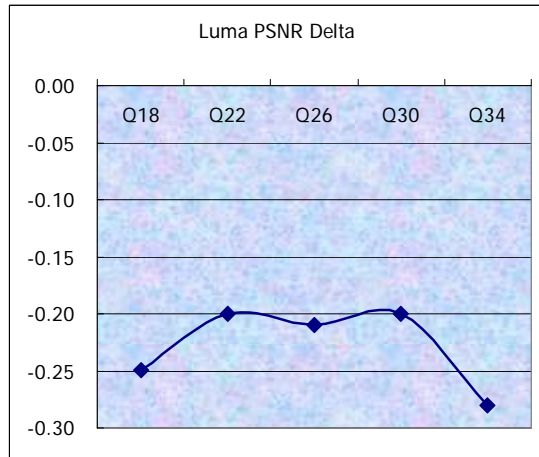


Chart 6- 5. football-90



352x288 IPP

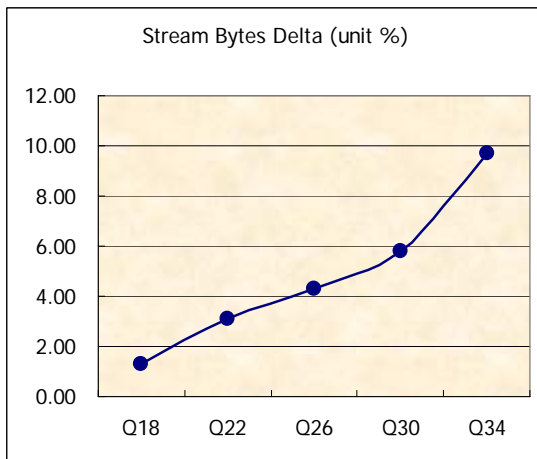
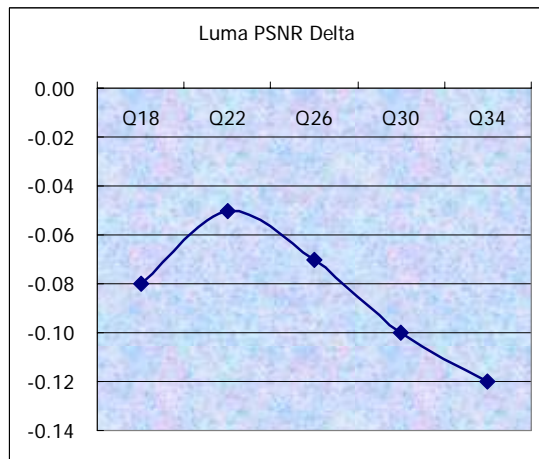


Chart 6- 6. foreman



352x288 IPP

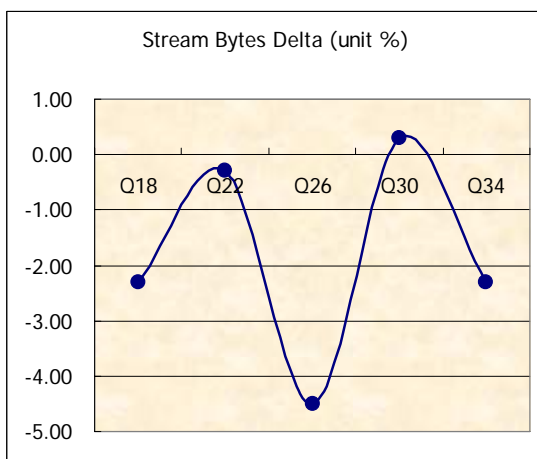
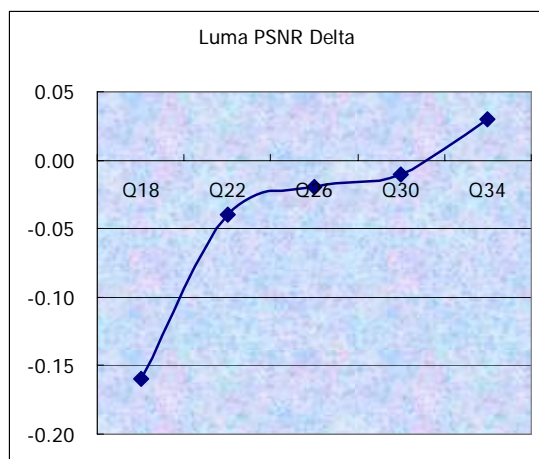


Chart 6- 7. hall_monitor



352x288 IPP

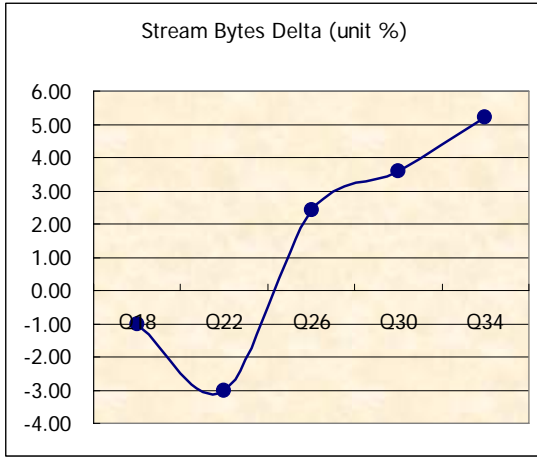
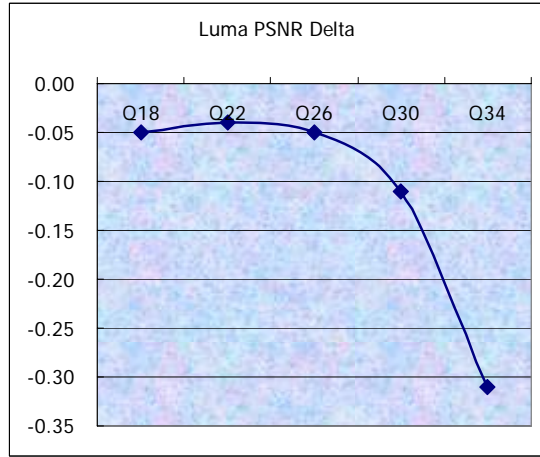


Chart 6- 8. highway



352x288 IPP

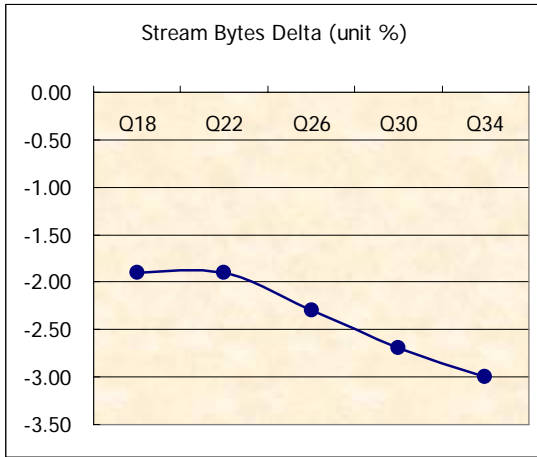
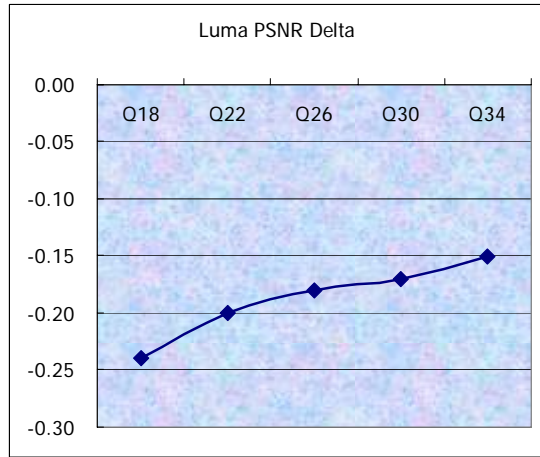


Chart 6- 9. husky



352x288 IPP

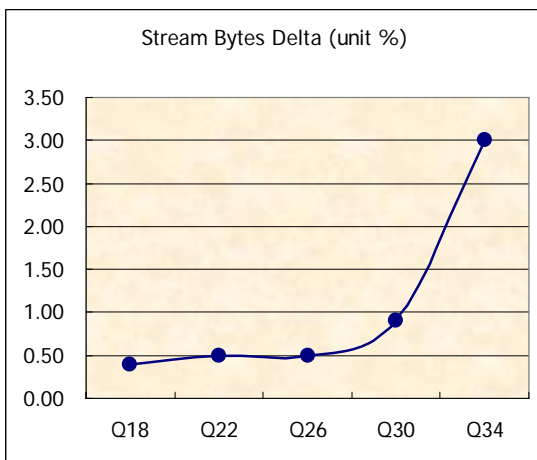
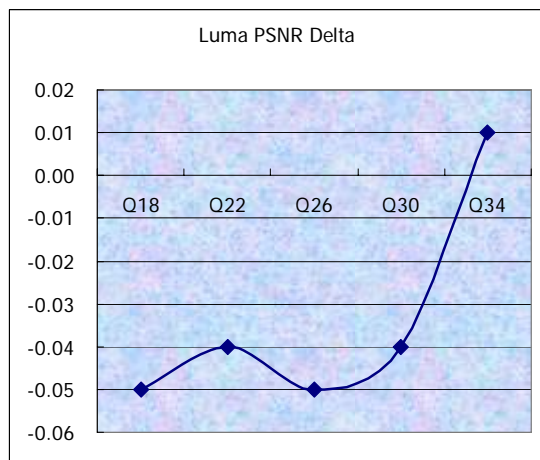


Chart 6-10. mobile



352x288 IPP

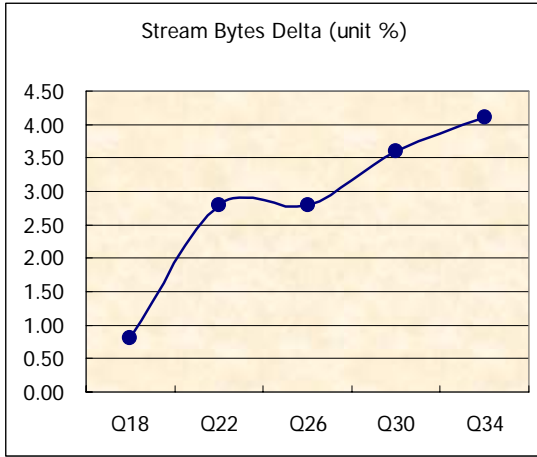
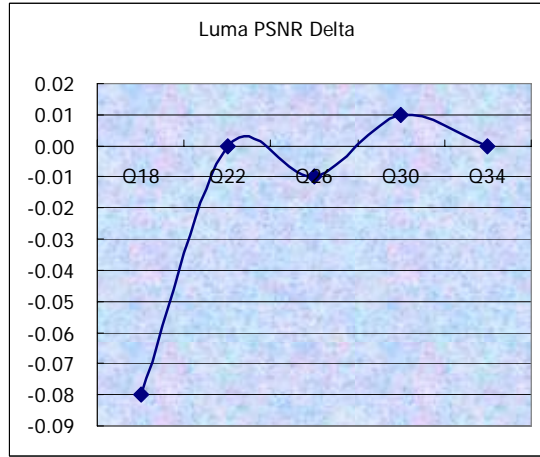


Chart 6-11. mother_daughter



352x288 IPP

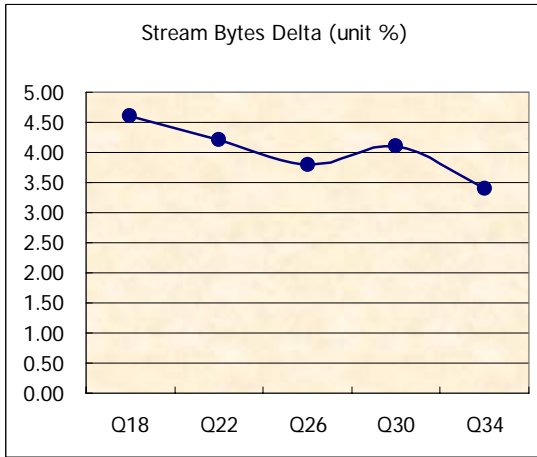
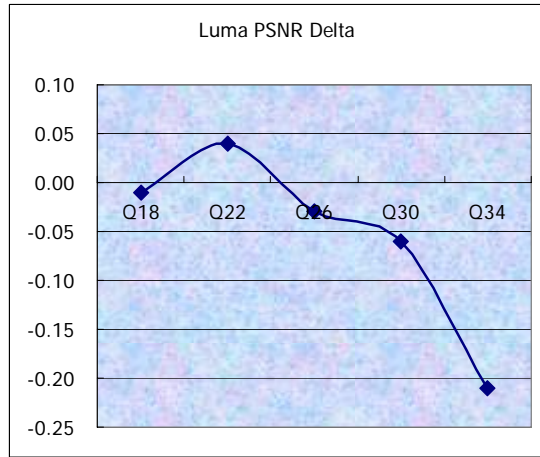


Chart 6-12. news



352x288 IPP

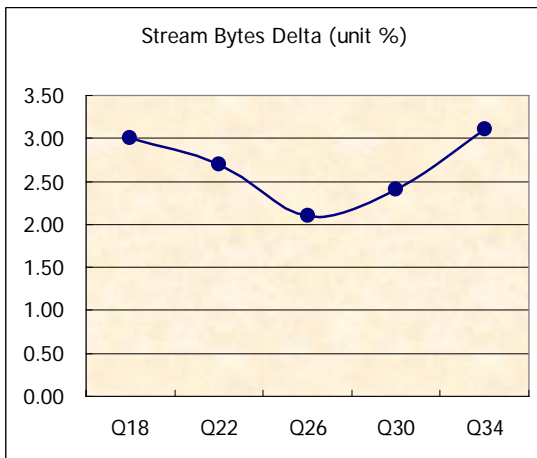
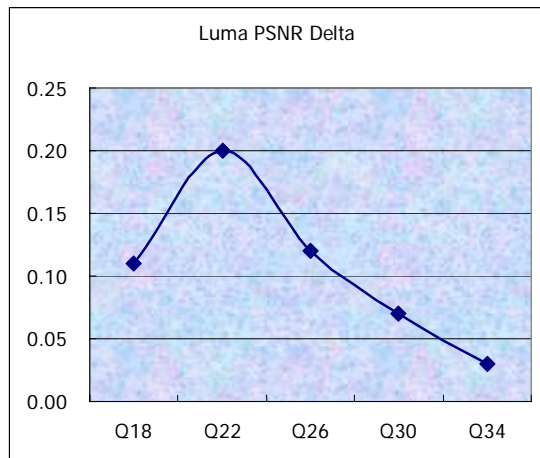


Chart 6-13. paris



352x288 IPP

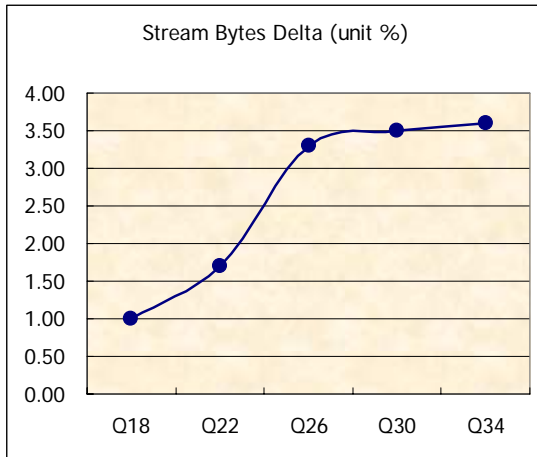
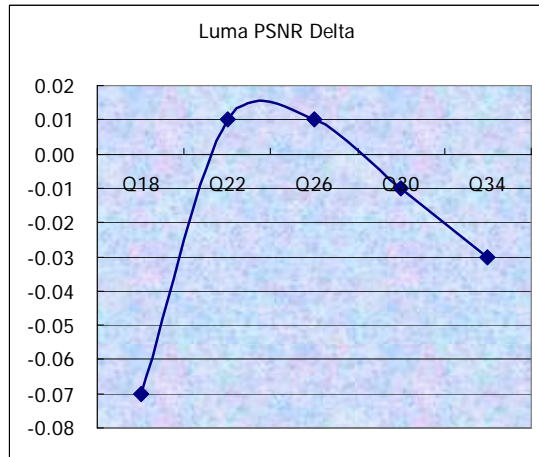


Chart 6-14. salesman



352x288 IPP

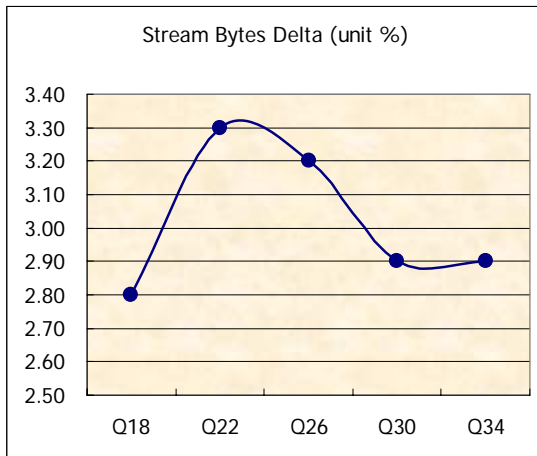
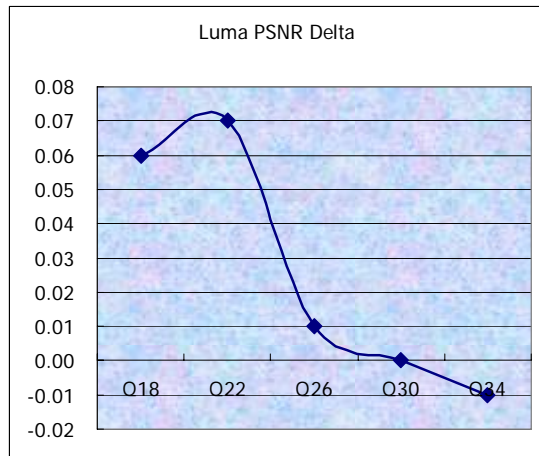


Chart 6-15. students



352x288 IPP

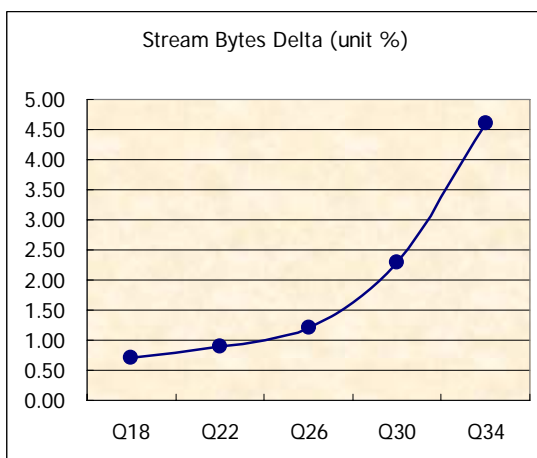
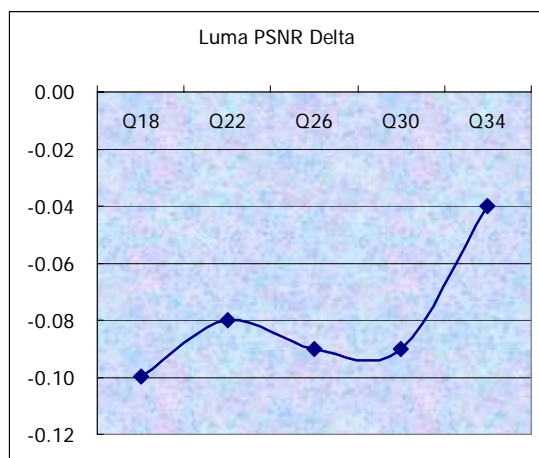


Chart 6-16. tempete



352x288 IPP

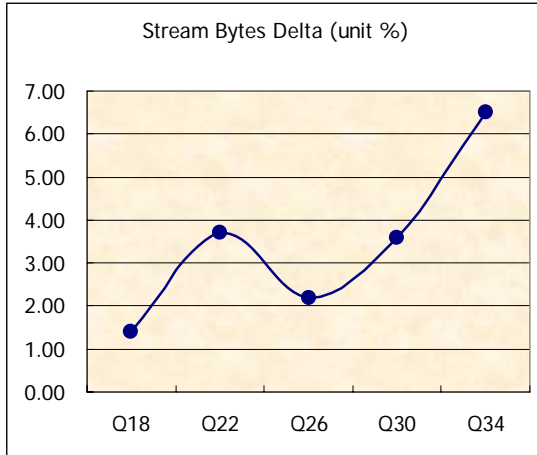
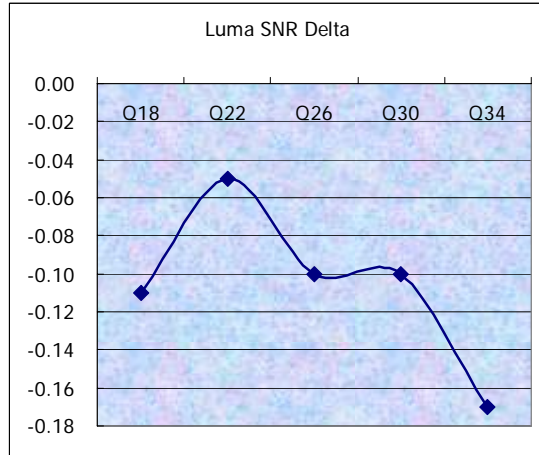


Chart 6-17. pedestrian_area



640x480 IPP

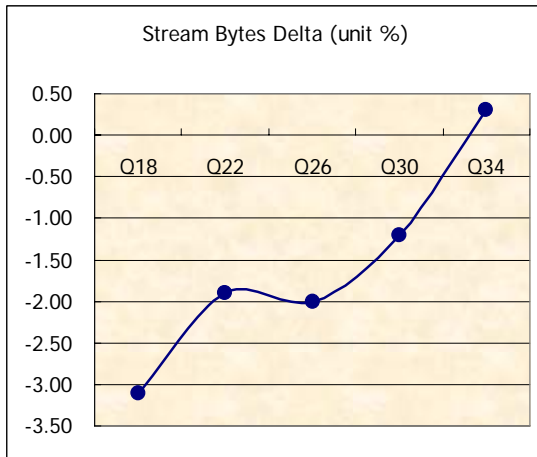
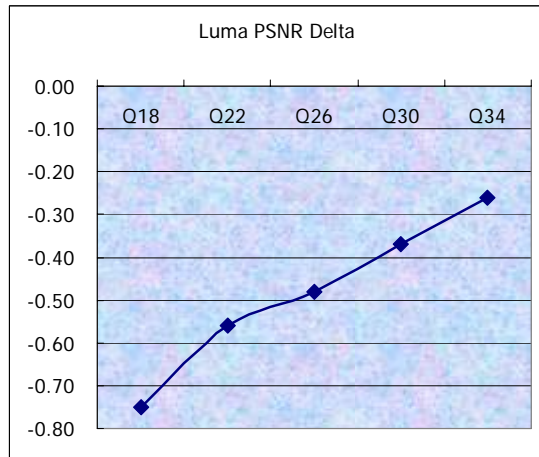


Chart 6-18. riverbed



640x480 IPP

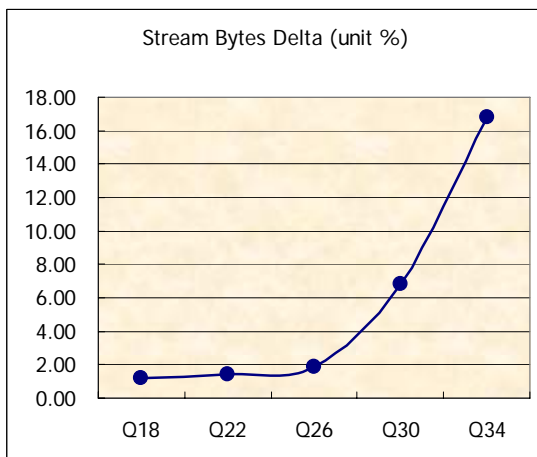
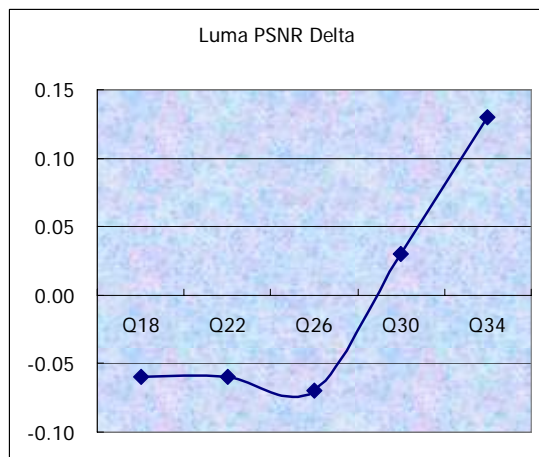


Chart 6-19. sunflower



640x480 IPP

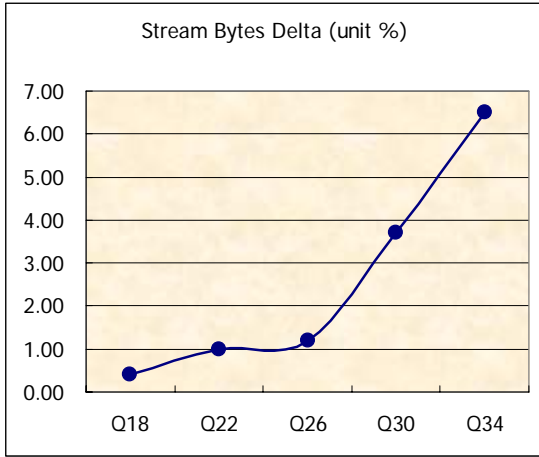
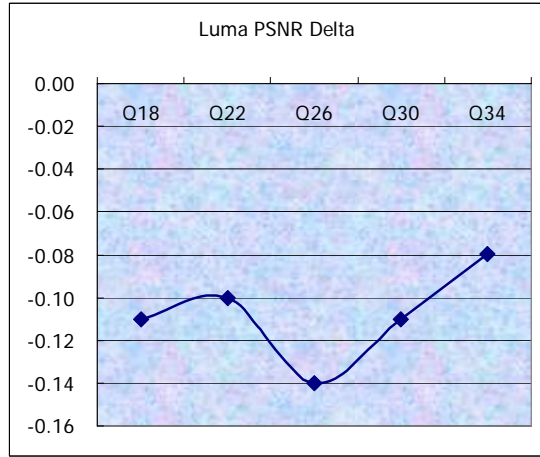


Chart 6-20.

tractor



640x480

IPP

7. Precise CBR Test

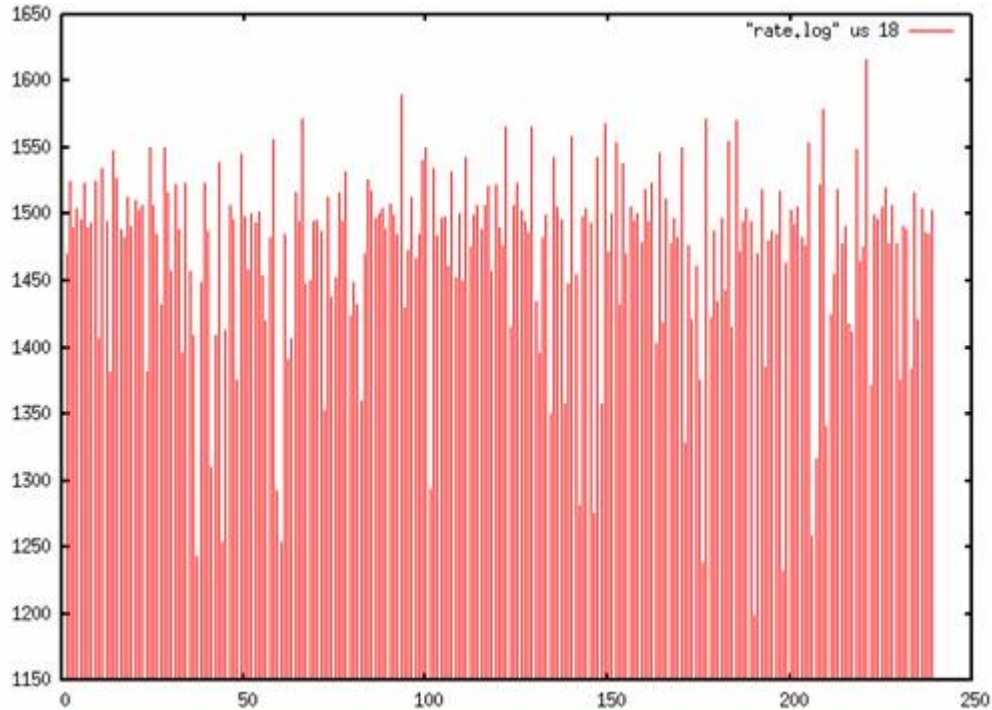
The Precise CBR is illustrated by two examples. The first video is the battle of Cannae in 216BC between Rome and Carthage, clipped from BBC HD video “Hannibal” and downsized from 720p to 720x480@30fps by bicubic algorithm:



The parameters of the script “run”:

```
./run -w 720 -h 480 -F /yuv-seqs/720x480/cannae-720x480.yuv -R 1500 -P 1 -T 2 -N 2 -k 300 -f 7200
```

The target rate is 1500 kbps.



This video contains all typical elements of cool steel battle: infantry, cavalry, panic and discipline, blood and cadaver, senators perished along with centurions and soldiers.... Every frame is highly clear and detailed, most of frames are full of intense and massive motions. Even for such an extreme clip, you can see in 240 seconds only one second the rate is slightly above $1500 * 105\% = 1575$ kbps

The PSNR for this clip:

Y: 41.57 U: 45.14 V: 44.44

Average rate for 7200 frames:

1472 kbps

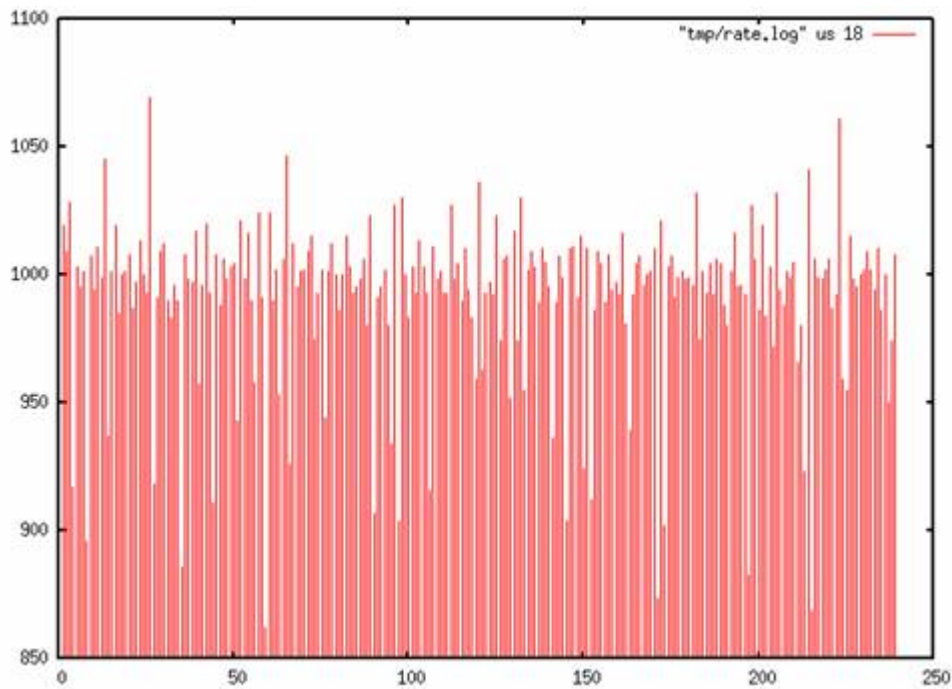
The second video is clipped from Digest of Euro Cup Soccer 2004 in Portugal. Downsized from top field of 1080i to progressive 720x480@30fps by bicubic algorithm:



The parameters of the script "run":

```
./run -w 720 -h 480 -F /yuv-seqs/720x480/soccer-euro-2004-720x480.yuv -R 1000 -P  
1 -T 2 -N 2 -k 300 -f 7200
```

The target rate is 1000 kbps.



This is another extraordinarily turbulent clip, the scenes always pan and zoom wildly while athletes fight fiercely and audiences riot frenetically. Sometimes scenes change several times in one second. All frames are highly clear and detailed, some frames shot in low light contain certain grains or noise but still sharp due to the professional camcorders. Still the motions in almost all frames are massive and intense. In this example, you can see only 2 seconds in 240 seconds (7200 frames) the rate is slightly above $100 \times 105\% = 1050$ kbps.

The PSNR for this Clip:

Y: 35.05 U: 39.19 V: 39.45

Average rate for 7200 fps:

992 kbps