

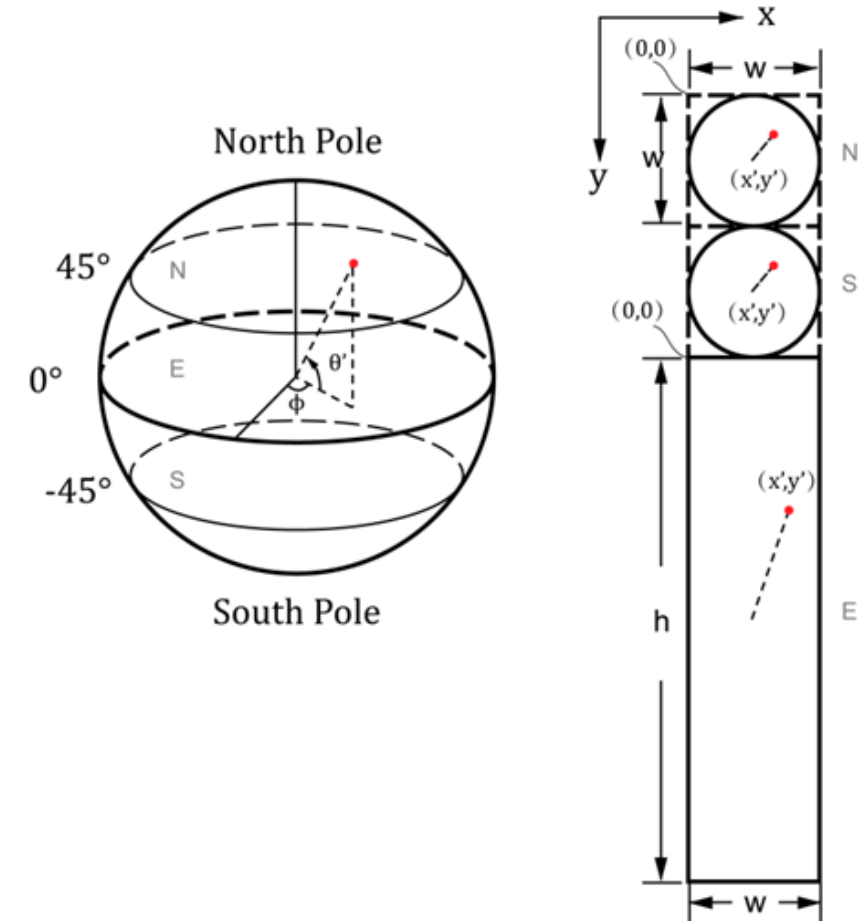
AHG8: Supplemental Test Results on Segmental Sphere Projection (SSP) JVET-E0113

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A Layout of SSP (Segmental Sphere Projection)

- Divide a sphere surface into three parts: North pole, middle and South pole.
- Sample allocation in projection:
 - In SSP 2/3 of samples are allocated to the middle part, and 1/3 of samples are allocated to the north and south pole part.
 - In ERP, 1/2 of samples are allocated to the middle part, and 1/2 of samples are allocated to the north and south pole part.



Viewport Quality at North and South Pole

- Can the reduced projection fidelity around North and South Pole undermine the viewport quality in that area?
- Experiments carried out by setting viewing directions to $(0, 90)$ and $(0, -90)$ in the JVET 360 video common test conditions, and by using the HM16.14 integrated with the 360 lib.

Experimental Results – SSP, AI & RA cfg.

	All Intra Main -10											
	CPP-PSNR			WS-PSNR (End to End)			PSNR_Viewport0			PSNR_Viewport1		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Tain	7.0%	-0.1%	0.8%	3.3%	7.0%	5.6%	34.1%	21.4%	27.9%	24.0%	59.2%	31.4%
Skateboarding_trick	8.8%	1.6%	1.8%	3.8%	4.3%	4.9%	34.7%	29.6%	15.9%	31.0%	52.5%	42.2%
Skateboarding_in_lot	4.6%	-6.7%	-5.7%	-6.3%	-6.1%	-5.4%	22.4%	24.2%	20.0%	34.1%	47.6%	16.0%
Chairlift	0.6%	-2.2%	-3.3%	-2.9%	-0.9%	-3.1%	17.2%	15.4%	16.1%	33.3%	41.6%	40.5%
KiteFlite	1.9%	-2.5%	-2.8%	-5.7%	-2.2%	-2.8%	13.4%	24.2%	20.4%	22.3%	28.3%	28.8%
Harbor	4.8%	-3.1%	-3.8%	-5.1%	-2.5%	-3.5%	18.5%	12.0%	10.0%	35.0%	42.3%	31.1%
PoleVault	2.9%	0.6%	0.4%	-3.1%	-5.0%	-4.8%	41.8%	31.4%	35.7%	30.6%	37.2%	32.1%
AerialCity	6.6%	4.0%	3.1%	1.1%	0.5%	-0.2%	31.5%	31.3%	33.1%	40.3%	36.3%	32.8%
DrivingInCity	7.0%	5.3%	5.6%	-2.5%	3.5%	3.4%	36.0%	35.8%	39.0%	31.6%	21.4%	25.0%
DirvingInCountry	6.4%	-1.5%	-0.9%	-3.5%	-3.4%	-3.3%	46.3%	27.7%	25.3%	36.3%	28.2%	33.0%
Overall	5.1%	-0.4%	-0.5%	-2.1%	-0.5%	-0.9%	29.6%	25.3%	24.3%	31.8%	39.5%	31.3%
	Random Access Main -10											
	CPP-PSNR			WS-PSNR (End to End)			PSNR_Viewport0			PSNR_Viewport1		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Tain	9.9%	2.5%	3.4%	5.9%	12.1%	9.8%	40.4%	26.4%	30.4%	28.6%	71.7%	40.4%
Skateboarding_trick	6.6%	-0.8%	-0.5%	2.7%	3.7%	4.9%	52.4%	43.7%	32.5%	37.9%	82.7%	58.6%
Skateboarding_in_lot	-8.0%	-14.2%	-15.0%	-15.1%	-13.5%	-14.6%	10.3%	17.2%	10.9%	8.6%	58.7%	-28.3%
Chairlift	-15.4%	-14.5%	-14.4%	-17.7%	-13.0%	-14.2%	4.9%	4.6%	4.4%	-1.0%	16.5%	13.8%
KiteFlite	1.7%	-3.0%	-3.7%	-8.2%	-2.5%	-3.4%	10.8%	26.2%	20.6%	29.7%	30.8%	29.6%
Harbor	7.2%	-0.2%	-0.6%	-6.8%	0.8%	-0.2%	18.1%	15.8%	14.9%	42.7%	50.9%	35.8%
PoleVault	-0.1%	1.2%	0.4%	-9.3%	-10.1%	-10.1%	69.3%	38.9%	36.7%	38.2%	50.7%	40.5%
AerialCity	8.7%	4.6%	4.4%	-3.5%	-1.9%	-2.2%	36.0%	30.7%	31.9%	46.9%	41.4%	36.6%
DrivingInCity	7.5%	8.9%	9.1%	-3.8%	5.5%	4.9%	44.1%	43.7%	46.4%	51.2%	33.4%	37.5%
DirvingInCountry	-10.1%	-14.6%	-13.7%	-21.0%	-17.4%	-17.6%	26.6%	6.0%	6.4%	2.4%	11.2%	16.9%
Overall	0.8%	-3.0%	-3.1%	-7.7%	-3.6%	-4.3%	31.3%	25.3%	23.5%	28.5%	44.8%	28.1%

Experimental Results – SSP LD_B & LD_P

	Low-Delay B Main -10											
	CPP-PSNR			WS-PSNR (End to End)			PSNR_Viewport0			PSNR_Viewport1		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Tain	11.5%	2.9%	4.8%	7.6%	12.9%	11.4%	36.4%	24.5%	45.1%	32.4%	80.3%	43.0%
Skateboarding_trick	5.9%	-1.4%	-1.1%	2.4%	2.4%	3.8%	48.3%	36.0%	25.9%	37.6%	85.5%	58.0%
Skateboarding_in_lot	-10.1%	-17.2%	-16.6%	-17.4%	-17.0%	-16.5%	6.1%	10.3%	20.7%	12.5%	105.9%	-6.0%
Chairlift	-11.0%	-9.5%	-8.1%	-13.3%	-8.0%	-7.9%	8.0%	13.0%	13.3%	24.8%	41.4%	46.3%
KiteFlite	-0.3%	-7.2%	-9.2%	-9.2%	-6.8%	-8.9%	20.2%	32.3%	26.6%	32.9%	34.5%	36.0%
Harbor	12.2%	5.3%	1.0%	-0.4%	6.0%	1.4%	30.2%	36.4%	21.9%	63.6%	82.0%	43.9%
PoleVault	-3.9%	-4.0%	-4.7%	-12.3%	-15.4%	-15.5%	71.8%	57.0%	55.5%	47.5%	64.8%	57.6%
AerialCity	1.5%	1.6%	0.9%	-9.0%	-5.2%	-6.1%	45.2%	53.6%	51.0%	54.9%	56.3%	48.8%
DrivingInCity	8.0%	7.7%	7.4%	-2.9%	4.6%	3.5%	51.1%	53.9%	55.0%	47.7%	39.7%	37.8%
DirvingInCountry	-13.1%	-16.3%	-15.3%	-23.7%	-18.9%	-19.1%	23.8%	-5.0%	-9.6%	15.9%	26.3%	40.2%
Overall	0.1%	-3.8%	-4.1%	-7.8%	-4.6%	-5.4%	34.1%	31.2%	30.5%	37.0%	61.7%	40.6%
	Low-Delay P Main -10											
	CPP-PSNR			WS-PSNR (End to End)			PSNR_Viewport0			PSNR_Viewport1		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Tain	11.3%	3.3%	5.3%	7.5%	13.3%	12.0%	38.2%	32.1%	42.5%	32.7%	83.4%	46.5%
Skateboarding_trick	5.6%	0.0%	0.2%	2.2%	3.6%	5.0%	48.2%	35.3%	26.8%	36.3%	80.7%	61.4%
Skateboarding_in_lot	-9.8%	-16.0%	-15.4%	-17.2%	-15.8%	-15.3%	10.7%	14.4%	22.5%	12.7%	112.1%	2.2%
Chairlift	-10.8%	-9.5%	-8.5%	-13.2%	-8.0%	-8.3%	7.1%	5.8%	4.8%	24.8%	37.0%	40.5%
KiteFlite	-1.0%	-7.9%	-9.6%	-10.1%	-7.5%	-9.4%	18.1%	29.4%	25.7%	32.6%	32.7%	34.6%
Harbor	11.7%	5.2%	0.3%	-1.2%	6.0%	0.7%	29.3%	41.1%	22.1%	63.7%	84.4%	47.1%
PoleVault	-5.1%	-4.9%	-5.9%	-13.9%	-16.6%	-16.9%	61.3%	44.6%	41.9%	46.0%	60.1%	52.6%
AerialCity	0.8%	-0.3%	-0.7%	-9.9%	-7.4%	-7.9%	42.5%	42.8%	37.1%	54.6%	52.6%	46.6%
DrivingInCity	8.0%	8.0%	8.0%	-3.0%	5.0%	4.3%	49.8%	40.2%	35.8%	47.6%	35.8%	37.8%
DirvingInCountry	-12.5%	-14.2%	-13.2%	-23.4%	-16.8%	-17.0%	24.7%	5.4%	3.3%	16.6%	26.8%	40.8%
Overall	-0.2%	-3.6%	-4.0%	-8.2%	-4.4%	-5.3%	33.0%	29.1%	26.2%	36.8%	60.6%	41.0%

Additional Experiments

- Is viewport quality loss around North and South pole common to alternative projection format (e.g. CMP, CISP)
- Experiments carried out by setting viewing directions to $(0, 0)$ and $(0, 90)$ in the JVET 360 video common test conditions, and by using the HM16.14 integrated with the 360 lib.

Experimental Results – VP0 (0, 0) VP1 (0, 90), ERP vs. SSP

	Random Access Main -10											
	CPP-PSNR			WS-PSNR (End to End)			PSNR_Viewport0			PSNR_Viewport1		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Tain	9.9%	2.5%	3.4%	5.9%	12.1%	9.8%	3.0%	1.4%	1.0%	40.4%	26.4%	30.4%
Skateboarding_trick	6.6%	-0.8%	-0.5%	2.7%	3.7%	4.9%	0.2%	-2.4%	-2.3%	52.4%	43.7%	32.5%
Skateboarding_in_lot	-8.0%	-14.2%	-15.0%	-15.1%	-13.5%	-14.6%	-20.9%	-18.5%	-17.4%	10.3%	17.2%	10.9%
Chairlift	-15.4%	-14.5%	-14.4%	-17.7%	-13.0%	-14.2%	-24.1%	-26.3%	-26.3%	4.9%	4.6%	4.4%
KiteFlite	1.7%	-3.0%	-3.7%	-8.2%	-2.5%	-3.4%	-13.8%	-11.7%	-12.3%	10.8%	26.2%	20.6%
Harbor	7.2%	-0.2%	-0.6%	-6.8%	0.8%	-0.2%	-17.7%	-6.0%	-6.4%	18.1%	15.8%	14.9%
PoleVault	-0.1%	1.2%	0.4%	-9.3%	-10.1%	-10.1%	-15.4%	-20.4%	-18.1%	69.3%	38.9%	36.7%
AerialCity	8.7%	4.6%	4.4%	-3.5%	-1.9%	-2.2%	-9.6%	-9.2%	-9.7%	36.0%	30.7%	31.9%
DrivingInCity	7.5%	8.9%	9.1%	-3.8%	5.5%	4.9%	-5.0%	-2.9%	-3.5%	44.1%	43.7%	46.4%
DirvingInCountry	-10.1%	-14.6%	-13.7%	-21.0%	-17.4%	-17.6%	-24.4%	-22.3%	-22.8%	26.6%	6.0%	6.4%
Overall	0.8%	-3.0%	-3.1%	-7.7%	-3.6%	-4.3%	-12.8%	-11.8%	-11.8%	31.3%	25.3%	23.5%

Experimental Results – VP0 (0, 0) VP1 (0, 90), ERP vs. CMP

	Random Access Main -10											
	CPP-PSNR			WS-PSNR (End to End)			PSNR_Viewport0			PSNR_Viewport1		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Tain	17.7%	10.5%	8.7%	11.3%	12.6%	10.9%	14.1%	17.3%	15.6%	19.9%	19.8%	18.8%
Skateboarding_trick	12.4%	7.5%	6.9%	9.7%	9.3%	9.3%	11.8%	13.7%	15.1%	33.4%	29.6%	34.2%
Skateboarding_in_lot	-6.0%	-8.8%	-10.4%	-8.5%	-9.6%	-10.8%	-6.8%	-8.2%	-6.4%	-6.1%	0.5%	-4.8%
Chairlift	-15.6%	-13.5%	-14.0%	-18.2%	-13.3%	-14.2%	-20.1%	-18.9%	-18.3%	11.5%	4.3%	5.5%
KiteFlite	1.2%	-1.8%	-3.8%	-4.9%	-1.5%	-3.8%	-4.6%	-2.8%	-6.0%	30.8%	32.0%	22.5%
Harbor	5.9%	-3.3%	-2.2%	1.1%	-3.0%	-2.1%	-1.7%	-3.9%	-3.6%	-4.3%	3.7%	-0.7%
PoleVault	-0.5%	-2.9%	-3.2%	-2.4%	-5.8%	-4.9%	-3.5%	-9.1%	-7.0%	43.9%	39.5%	36.8%
AerialCity	11.2%	7.4%	7.4%	4.2%	3.7%	3.6%	2.7%	0.4%	-0.2%	38.3%	33.2%	37.4%
DrivingInCity	8.9%	9.1%	10.7%	4.8%	7.2%	9.2%	9.9%	6.8%	9.5%	47.7%	46.3%	50.3%
DirvingInCountry	-9.7%	-12.7%	-11.5%	-14.6%	-14.3%	-13.6%	-9.1%	-13.9%	-10.9%	-10.8%	-10.7%	-8.6%
Overall	2.6%	-0.9%	-1.1%	-1.7%	-1.5%	-1.6%	-0.7%	-1.8%	-1.2%	20.4%	19.8%	19.1%

Experimental Results – VP0 (0, 0) VP1 (0, 90), ERP vs. CISP

	Random Access Main -10											
	CPP-PSNR			WS-PSNR (End to End)			PSNR_Viewport0			PSNR_Viewport1		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Tain	23.6%	12.8%	12.8%	13.4%	14.9%	15.1%	7.5%	8.2%	8.1%	44.7%	32.8%	31.9%
Skateboarding_trick	10.1%	-0.5%	1.1%	2.2%	1.0%	3.5%	-4.3%	-6.5%	-3.5%	37.4%	27.6%	29.1%
Skateboarding_in_lot	4.7%	-4.0%	-4.0%	-5.3%	-6.2%	-6.0%	-13.4%	-9.3%	-7.3%	15.9%	28.3%	15.4%
Chairlift	-9.1%	-6.2%	-6.9%	-14.8%	-6.6%	-7.8%	-21.1%	-20.5%	-18.4%	5.1%	10.0%	10.8%
KiteFlite	6.0%	1.4%	-0.5%	-5.7%	1.3%	-0.7%	-14.6%	-11.1%	-13.8%	13.5%	31.8%	21.1%
Harbor	16.7%	4.3%	4.4%	-1.1%	3.8%	3.8%	-14.8%	-0.7%	-1.4%	20.3%	23.4%	17.1%
PoleVault	1.4%	2.1%	1.4%	-5.9%	-6.0%	-6.3%	-15.7%	-16.8%	-17.2%	41.1%	42.0%	42.1%
AerialCity	14.1%	12.3%	11.7%	4.9%	6.6%	6.2%	-3.5%	-3.4%	-4.2%	38.5%	37.0%	38.8%
DrivingInCity	24.9%	22.2%	23.6%	12.5%	18.7%	19.5%	3.4%	7.5%	7.0%	55.3%	58.1%	60.3%
DirvingInCountry	-4.7%	-6.6%	-8.1%	-12.8%	-9.3%	-11.7%	-18.5%	-16.6%	-18.3%	5.9%	8.9%	1.6%
Overall	8.8%	3.8%	3.6%	-1.3%	1.8%	1.6%	-9.5%	-6.9%	-6.9%	27.8%	30.0%	26.8%

Inconsistent Behavior of WS-PSNR (1), SSP, RA Cfg.

SSP_Vertical vs. ERP	FW	FH	S-PSNR-NN			WS-PSNR			WS-PSNR (End to End)		
			Y	U	V	Y	U	V	Y	U	V
Train	1216	1216	7.9%	2.4%	2.3%	8.4%	7.8%	6.3%	5.2%	13.4%	9.8%
Skateboarding_trick	1216	1216	6.0%	-2.4%	-1.2%	6.5%	1.3%	2.9%	2.6%	3.5%	5.4%
Skateboarding_in_lot	1216	1216	-11.3%	-17.3%	-16.8%	-11.1%	-14.3%	-13.9%	-15.0%	-14.6%	-14.6%
Chairlift	1216	1216	-18.7%	-14.5%	-15.0%	-17.8%	-12.4%	-13.8%	-17.6%	-12.8%	-13.8%
KiteFlite	1216	1216	-0.1%	-3.4%	-4.0%	-0.2%	-3.0%	-3.6%	-8.2%	-2.8%	-3.5%
Harbor	1216	1216	5.1%	-0.9%	-0.5%	5.3%	0.7%	0.8%	-6.2%	0.9%	0.6%
PoleVault	1008	1008	-3.6%	-7.6%	-8.6%	-3.5%	-7.1%	-8.3%	-8.9%	-10.3%	-10.1%
AerialCity	1008	1008	-1.6%	-1.6%	-1.7%	-0.7%	2.1%	0.5%	-3.1%	-1.7%	-1.6%
DrivingInCity	1008	1008	3.0%	5.5%	4.8%	3.2%	10.8%	6.6%	-2.9%	5.4%	4.7%
DrivingInCountry	1008	1008	-15.1%	-16.9%	-17.4%	-14.8%	-14.7%	-16.0%	-20.4%	-16.8%	-17.5%
Overall			-2.8%	-5.7%	-5.8%	-2.5%	-2.9%	-3.8%	-7.5%	-3.6%	-4.1%

SSP vs. ERP	FW	FH	S-PSNR-NN			WS-PSNR			WS-PSNR (End to End)		
			Y	U	V	Y	U	V	Y	U	V
Train	1216	1216	8.6%	1.2%	2.3%	-9.4%	-8.2%	-4.9%	5.9%	12.1%	9.8%
Skateboarding_trick	1216	1216	6.2%	-2.1%	-1.5%	-22.9%	-25.6%	-21.5%	2.7%	3.7%	4.9%
Skateboarding_in_lot	1216	1216	-11.5%	-16.3%	-16.7%	-19.4%	-42.2%	-36.4%	-15.1%	-13.5%	-14.6%
Chairlift	1216	1216	-18.8%	-14.8%	-15.3%	-19.5%	-2.3%	-9.6%	-17.7%	-13.0%	-14.2%
KiteFlite	1216	1216	-0.2%	-3.1%	-4.0%	-5.9%	-5.5%	-9.4%	-8.2%	-2.5%	-3.4%
Harbor	1216	1216	4.5%	-1.1%	-1.3%	-4.7%	-15.9%	-16.0%	-6.8%	0.8%	-0.2%
PoleVault	1008	1008	-4.0%	-7.3%	-8.5%	-17.2%	-21.2%	-25.2%	-9.3%	-10.1%	-10.1%
AerialCity	1008	1008	-2.0%	-1.8%	-2.4%	-11.2%	3.6%	1.0%	-3.5%	-1.9%	-2.2%
DrivingInCity	1008	1008	2.2%	5.4%	4.9%	-22.5%	1.4%	-4.3%	-3.8%	5.5%	4.9%
DrivingInCountry	1008	1008	-15.6%	-17.6%	-17.6%	-25.5%	-25.7%	-34.1%	-21.0%	-17.4%	-17.6%
Overall			-3.1%	-5.7%	-6.0%	-15.8%	-14.2%	-16.1%	-7.7%	-3.6%	-4.3%

Observations and Discussions

- **Observations**

- Viewport quality loss around the North and South pole seems to be common to alternative projection formats (e.g. SSP, CMP, CISP).
- 360 video quality metrics do not agree with each other in some cases.
- Further study seems to be needed for the consistency and reliability of 360 video quality metrics.
- Hard to say one particular projection format, including SSP, is better than ERP in terms of compression efficiency. It is likely content dependent.
- ERP performs reasonably well in terms of compression efficiency despite of redundant samples around the North and South Pole

- **Discussions:**

- Can we say that viewport quality around the North and South Pole in ERP is too good (no compression considered here) compared to viewport quality of other viewing directions?
- What happens if the North and/or South Pole happens to be a busy area? Would the viewport quality loss around the North and South Pole become visible in this case?
- What happens if rate control is in place in which bit-rate can be shifted from the North and South Pole area to the middle part of sphere?
- How reliable is the BD-rate calculation in high PSNR range?