

# CE6: Summary Report on Transforms and Transform Signalling

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# CE6 Overview

- **CE6-1: Primary Transform**
  - 21 CE tests, 11 proposals
  - 17 related proposals
  - Two test conditions: CTC, CTC w/ Inter MTS
- **CE6-2: Secondary Transform (CTC)**
  - 6 tests, 2 proposals
  - 1 related proposal
  - Test condition: CTC
- **CE6-3: Combination and Signaling (CTC)**
  - 7 tests, 3 proposals
  - Test condition: CTC

# CE6-1 Primary Transform

## Results Summary (CTC)

						All Intra					Random Access					Low Delay B				
CE Sub-Category	Test #	Doc. #	Tester	Crosscheckers	intra or inter	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1 Primary	CE6-1.1a	JVET-L029	LGE	HHI, b<>com		0.11%	0.21%	0.22%	78%	99%	0.06%	0.09%	0.12%	96%	100%	-0.05%	0.01%	0.10%	97%	101%
	CE6-1.1b	JVET-L029	LGE	HHI, b<>com		0.34%	-0.18%	-0.16%	62%	98%	0.15%	-0.12%	-0.08%	91%	100%	0.02%	-0.15%	-0.25%	96%	100%
	CE6-1.1c	JVET-L013	LGE	Qualcomm, HHI, b<>com		0.01%	0.00%	0.03%	97%	90%	0.01%	0.03%	0.04%	99%	99%	-0.01%	-0.06%	0.01%	99%	100%
	CE6-1.1d	JVET-L013	LGE	HHI, b<>com		0.11%	0.01%	0.01%	98%	95%	0.03%	0.02%	0.02%	99%	100%	0.02%	0.04%	-0.14%	100%	101%
	CE6-1.2a	JVET-L035	Huawei	Qualcomm	inter						-0.48%	0.21%	0.03%	109%	102%	-0.94%	-0.06%	-0.10%	114%	104%
	CE6-1.2b	JVET-L035	Huawei	Sony	inter						-0.61%	0.20%	0.00%	114%	102%	-1.02%	-0.04%	0.03%	122%	104%
	CE6-1.3a	JVET-L028	Tencent	Samsung	both	0.00%	0.00%	0.05%	99%	98%	0.01%	0.09%	0.07%	98%	98%	-0.01%	0.24%	-0.09%	98%	99%
	CE6-1.3b	JVET-L028	Tencent	Samsung, Huawei	both	0.01%	-0.08%	-0.01%	99%	97%	0.01%	0.03%	0.04%	99%	99%	-0.01%	0.16%	-0.20%	98%	99%
	CE6-1.4a	JVET-L028	Tencent	Samsung, Qualcomm, b<>	both	-0.01%	0.01%	0.04%	95%	89%	0.00%	0.03%	0.04%	98%	98%	-0.04%	-0.18%	-0.31%	98%	98%
	CE6-1.6a	JVET-L038	Qualcomm	Tencent, b<>com	both	0.03%	0.01%	0.06%	98%	90%	0.02%	0.02%	0.09%	99%	98%	0.02%	-0.07%	0.08%	100%	99%
	CE6-1.6b	JVET-L013	Orange	Qualcomm, Tencent	both	0.06%	0.04%	0.07%	97%	88%	0.05%	0.05%	0.07%	99%	98%	-0.02%	-0.07%	-0.08%	99%	100%
	CE6-1.6c	JVET-L038	Qualcomm	b<>com	both, 64x64	-0.02%	-0.06%	-0.06%	98%	91%	-0.07%	-0.26%	-0.23%	101%	98%	-0.05%	-0.23%	-0.47%	101%	101%
	CE6-1.7a	JVET-L026	Technicolor	Tencent	both	0.23%	0.08%	0.08%	101%	95%	0.19%	0.22%	0.22%	99%	98%	0.05%	0.05%	-0.11%	97%	97%
	CE6-1.7b	JVET-L011	Panasonic	Sony	inter															
	CE6-1.7c	JVET-L011	Panasonic	Sony	both	0.23%	0.08%	0.08%	101%	95%	0.19%	0.22%	0.22%	99%	98%	0.05%	0.05%	-0.11%	97%	97%
	CE6-1.7d		Sony, Technicolor	Panasonic	intra	-0.21%	-0.18%	-0.15%	97%	95%	-0.07%	0.00%	0.02%	97%	97%	-0.10%	0.13%	-0.29%	96%	95%
	CE6-1.7e		Sony, Technicolor	Panasonic	both	0.08%	0.02%	0.06%	98%	93%	0.11%	0.17%	0.14%	97%	97%	-0.01%	-0.24%	-0.15%	96%	95%
	CE6-1.7f	JVET-L028	Tencent	Technicolor, Huawei	both	0.06%	0.07%	0.14%	99%	97%	0.08%	0.13%	0.15%	99%	98%	0.15%	0.12%	-0.18%	97%	96%
	CE6-1.7g	JVET-L028	Tencent	Technicolor	both	-0.05%	-0.07%	-0.06%	100%	99%	0.09%	0.09%	0.12%	99%	99%	0.08%	0.10%	0.06%	98%	98%
	CE6-1.8a	JVET-L026	Technicolor	Sony		-0.05%	0.09%	0.11%	101%	100%	-0.02%	0.09%	0.06%	100%	100%	-0.04%	0.05%	-0.27%	101%	101%
	CE6-1.8b	JVET-L026	Technicolor	Sony		0.03%	0.14%	0.14%	101%	98%	0.08%	0.16%	0.22%	100%	101%	-0.03%	-0.03%	-0.01%	100%	99%

# CE6-1 Primary Transform

## Results Summary, CTC w/ inter MTS enabled

						All Intra					Random Access					Low Delay B				
CE Sub-Category	Test #	Doc. #	Tester	Crosscheckers	intra or inter	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1 Primary	CE6-1.1a	JVET-L029	LGE	HHI, b<>com		0.11%	0.21%	0.22%	78%	99%	0.04%	0.08%	0.15%	96%	100%	-0.02%	-0.06%	0.21%	99%	100%
	CE6-1.1b	JVET-L029	LGE	HHI, b<>com		0.34%	-0.18%	-0.16%	62%	98%	0.14%	-0.21%	-0.06%	93%	100%	0.03%	-0.14%	0.20%	97%	100%
	CE6-1.1c	JVET-L013	LGE	Qualcomm, HHI, b<>com		0.01%	0.00%	0.03%	97%	90%	0.00%	-0.06%	0.05%	97%	97%	0.00%	0.04%	0.25%	97%	96%
	CE6-1.1d	JVET-L013	LGE	HHI, b<>com		0.11%	0.01%	0.01%	98%	95%	0.04%	-0.02%	-0.01%	96%	98%	0.03%	0.07%	-0.05%	96%	98%
	CE6-1.2a	JVET-L035	Huawei	Qualcomm	inter						-0.37%	0.03%	-0.04%	107%	101%	-0.60%	-0.30%	-0.12%	110%	100%
	CE6-1.2b	JVET-L035	Huawei	Sony	inter						-0.45%	0.07%	-0.03%	110%	100%	-0.65%	-0.32%	-0.03%	114%	100%
	CE6-1.3a	JVET-L028	Tencent	Samsung	both	0.00%	0.00%	0.05%	99%	98%	0.02%	0.04%	0.11%	100%	99%	-0.02%	0.26%	-0.01%	100%	100%
	CE6-1.3b	JVET-L028	Tencent	Samsung, Huawei	both	0.01%	-0.08%	-0.01%	99%	97%	0.02%	-0.08%	0.00%	100%	99%					
	CE6-1.4a	JVET-L028	Tencent	Samsung, Qualcomm, b<>	both	-0.01%	0.01%	0.04%	95%	89%	0.00%	-0.03%	0.07%	96%	97%	-0.01%	-0.12%	0.02%	97%	97%
	CE6-1.6a	JVET-L038	Qualcomm	Tencent, b<>com	both	0.03%	0.01%	0.06%	98%	90%	0.01%	-0.05%	0.03%	97%	96%	-0.01%	-0.21%	0.46%	97%	95%
	CE6-1.6b	JVET-L013	Orange	Qualcomm, Tencent	both	0.06%	0.04%	0.07%	97%	88%	0.03%	0.03%	0.06%	96%	96%	0.00%	0.00%	0.05%	96%	96%
	CE6-1.6c	JVET-L038	Qualcomm	b<>com	both, 64x64	-0.02%	-0.06%	-0.06%	98%	90%	-0.14%	-0.19%	-0.19%	104%	96%	-0.18%	-0.03%	-0.35%	104%	95%
	CE6-1.7a	JVET-L026	Technicolor	Tencent	both	0.23%	0.08%	0.08%	101%	95%	0.14%	0.06%	0.16%	100%	97%	-0.17%	-0.12%	-0.01%	101%	99%
	CE6-1.7b	JVET-L011	Panasonic	Sony	inter						0.01%	0.04%	0.03%	98%	97%	0.01%	0.10%	0.53%	99%	98%
	CE6-1.7c	JVET-L011	Panasonic	Sony	both	0.23%	0.08%	0.08%	101%	95%	0.14%	0.01%	0.14%	100%	97%	-0.16%	-0.03%	0.14%	101%	99%
	CE6-1.7d		Sony, Tech	Panasonic	intra	-0.21%	-0.18%	-0.15%	97%	95%	-0.08%	-0.04%	0.01%	98%	97%	-0.08%	0.20%	0.09%	99%	98%
	CE6-1.7e		Sony, Tech	Panasonic	both	0.08%	0.02%	0.06%	98%	93%	0.07%	0.01%	0.06%	100%	96%	-0.22%	-0.22%	-0.14%	100%	98%
	CE6-1.7f	JVET-L028	Tencent	Technicolor, Huawei	both	0.06%	0.07%	0.14%	99%	97%	0.06%	0.07%	0.16%	99%	97%	0.07%	0.21%	0.13%	100%	100%
	CE6-1.7g	JVET-L028	Tencent	Technicolor	both	-0.05%	-0.07%	-0.06%	100%	99%	0.03%	0.00%	0.11%	101%	99%	-0.07%	0.05%	0.16%	101%	101%
	CE6-1.8a	JVET-L026	Technicolor	Sony							-0.01%	0.01%	0.05%							
	CE6-1.8b	JVET-L026	Technicolor	Sony							0.05%	0.02%	0.09%							

# CE6-1 Primary Transform

- Simplification

- Transform core reduction
  - CE6-1.7a/f/g: Bases sharing between different transform types
- Transform core precision
  - CE6-1.3: 8-bit transform
- Unification
  - CE6-1.7b
- Fast transform
  - CE6-1.1c, CE6-1.4, CE6-1.6: fast DST7/DCT8
  - CE6-1.1a/b\*: Modified MTS
  - CE6-1.1d: zero-out MTS

- Coding efficiency

- Sub-block transform
  - CE6-1.2: SVT\*
- More flexible MTS
  - CE6-1.7 d/e
  - CE6-1.8
- MTS for larger size
  - CE6-1.6c\*

\*Contain CE description modification after T3

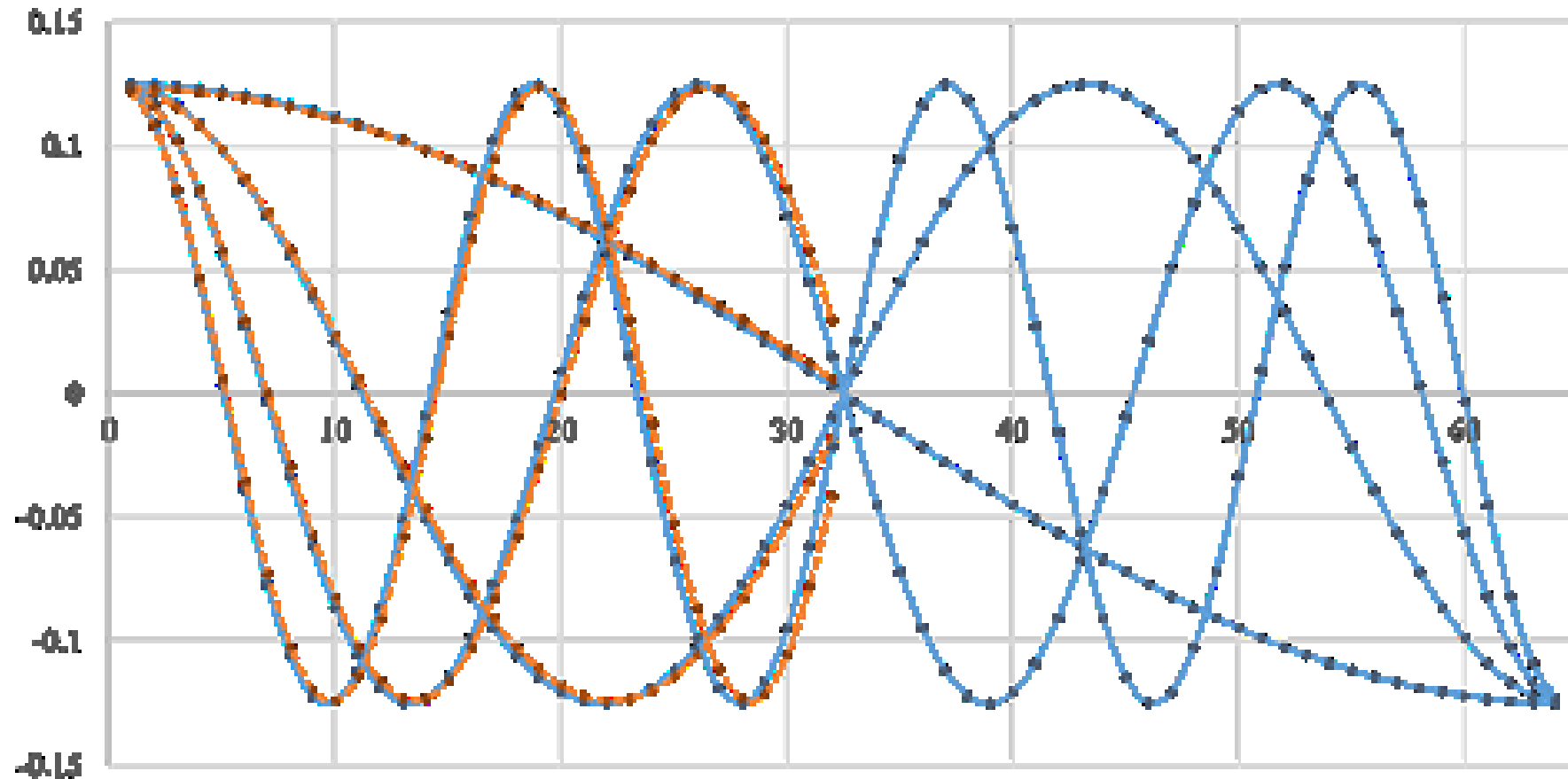
# CE6-1 Primary Transform

- Transform core reduction

Test #	Description	Memory reduction
6.1.7-a	AMT intra: DST-4 / DCT-4 AMT inter: DCT-4 / DST-4 Max AMT size: 32	3.4 KB (40%)
6.1.7-f	32- and 64-point DCT-2 replaced by COT AMT intra: DST-7 / DCT-8 AMT inter: DCT-8 / DST-7 Max AMT size: 32	3.2 KB (38%)
6.1.7-g	32- and 64-point DCT-2 replaced by COT 16-point and 32-point: AMT intra: DST-7 / DCT-8 AMT inter: DCT-8 / DST-7 4-point and 8-point: AMT intra: DST-4 / DCT-4 AMT inter: DCT-4 / DST-4 Max AMT size: 32	3.4 KB (40%)

# CE6-1 Primary Transform

- Transform bases sharing



# CE6-1 Primary Transform

- Transform core reduction

Test #	Test Condition	All Intra					Random Access					Low Delay B				
		Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1.7a	CTC	0.23%	0.08%	0.08%	101%	95%	0.19%	0.22%	0.22%	99%	98%	0.05%	0.05%	-0.11%	97%	97%
CE6-1.7f	CTC	0.06%	0.07%	0.14%	99%	97%	0.08%	0.13%	0.15%	99%	98%	0.15%	0.12%	-0.18%	97%	96%
CE6-1.7g	CTC	-0.05%	-0.07%	-0.06%	100%	99%	0.09%	0.09%	0.12%	99%	99%	0.08%	0.10%	0.06%	98%	98%
CE6-1.7a	CTC + Inter MTS	0.23%	0.08%	0.08%	101%	95%	0.14%	0.06%	0.16%	100%	97%	-0.17%	-0.12%	-0.01%	101%	99%
CE6-1.7f	CTC + Inter MTS	0.06%	0.07%	0.14%	99%	97%	0.06%	0.07%	0.16%	99%	97%	0.07%	0.21%	0.13%	100%	100%
CE6-1.7g	CTC + Inter MTS	-0.05%	-0.07%	-0.06%	100%	99%	0.03%	0.00%	0.11%	101%	99%	-0.07%	0.05%	0.16%	101%	101%



# CE6-1 Primary Transform

- Transform core precision
  - CE6-1.3: 8-bit transform
    - All HEVC transforms are kept as is
    - Proposed 8-bit 64-pt DCT-2, 8-pt~32-pt DST-7, 4-pt~32-pt DCT-8

Test #	Description
6.1.3-a	Primary transform core with 8-bit precision for both forward and backward transform
6.1.3-b	Primary transform core with 8-bit precision for only backward transform

# CE6-1 Primary Transform

- CE6-1.3: 8-bit transform

CTC Sequences		All Intra					Random Access					Low Delay B				
Test #	Test Condition	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1.3a	CTC	0.00%	0.00%	0.05%	99%	98%	0.01%	0.09%	0.07%	98%	98%	-0.01%	0.24%	-0.09%	98%	99%
CE6-1.3b	CTC	0.01%	-0.08%	-0.01%	99%	97%	0.01%	0.03%	0.04%	99%	99%	-0.01%	0.16%	-0.20%	98%	99%
CE6-1.3a	CTC + Inter MTS	0.00%	0.00%	0.05%	99%	98%	0.02%	0.04%	0.11%	100%	99%	-0.02%	0.26%	-0.01%	100%	100%
CE6-1.3b	CTC + Inter MTS	0.01%	-0.08%	-0.01%	99%	98%	0.02%	-0.08%	0.00%	100%	99%					
CE6-1.3a	CTC, Low QP	0.06%	0.08%	0.07%	100%	100%										
CE6-1.3b	CTC, Low QP	0.05%	-0.01%	0.00%	100%	100%										
CE6-1.3a	CTC + Inter MTS, Low QP	0.06%	0.08%	0.07%	100%	99%	0.02%	0.02%	0.04%	100%	100%					
CE6-1.3b	CTC + Inter MTS, Low QP	0.05%	-0.01%	0.00%	100%	100%	0.03%	-0.05%	-0.05%	100%	100%					

HDR Sequences		All Intra								Random Access							
Test #	Test Condition	DE100	PSNRL100	wPsnrY	wPsnrU	wPsnrV	psnrY	psnrU	psnrV	DE100	PSNRL100	wPsnrY	wPsnrU	wPsnrV	psnrY	psnrU	psnrV
CE6-1.3a	CTC	0.00%	-0.01%	-0.01%	0.07%	-0.08%	0.00%	0.10%	0.04%	0.13%	-0.02%	-0.01%	-0.17%	-0.19%	-0.02%	-0.30%	-0.22%
CE6-1.3b	CTC	-0.02%	0.00%	-0.01%	-0.11%	-0.05%	-0.01%	-0.09%	-0.05%	0.00%	-0.02%	-0.01%	-0.33%	-0.31%	-0.01%	-0.41%	-0.33%

# CE6-1 Primary Transform

- Unification

- Align the semantics of mts\_idx for intra and inter

Test #	Description
6.1.7-b	AMT intra: DST-7 / DCT-8 AMT inter: DST-7 / DCT-8 (align mts_idx as intra) Max AMT size: 32

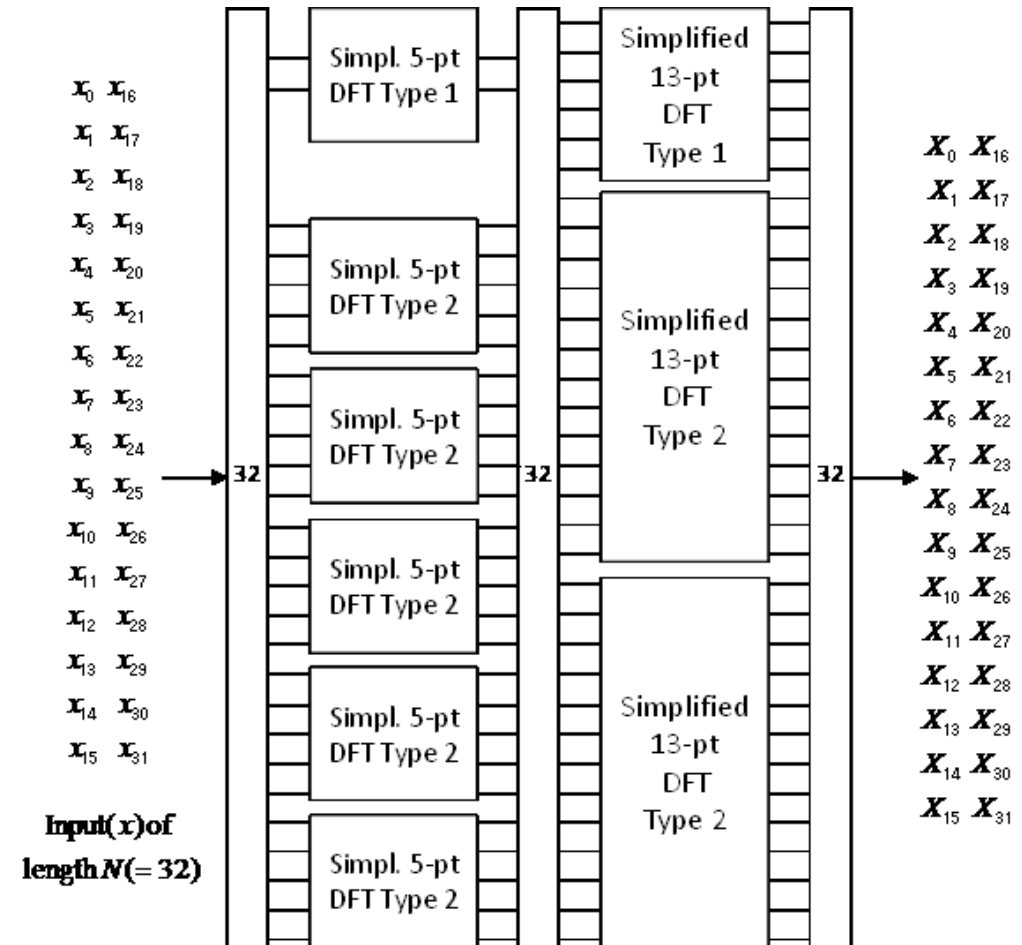
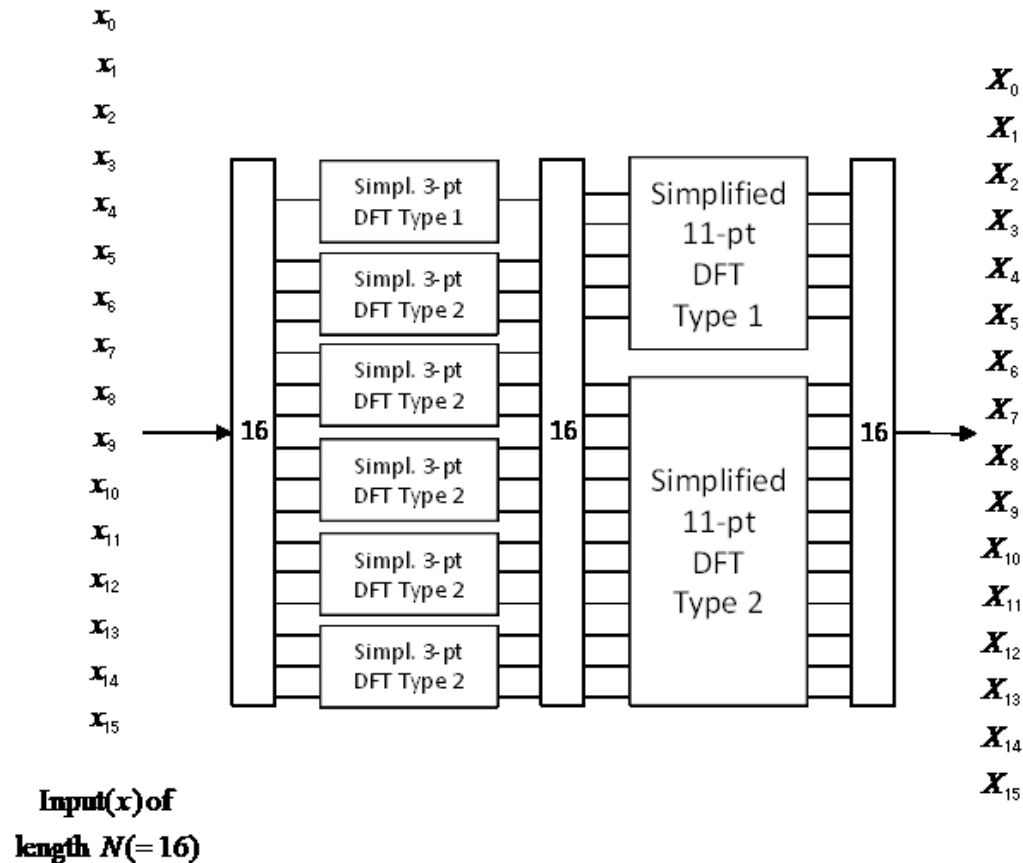
		Random Access					Low Delay B				
Test #	Test Condition	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1.7b	CTC + Inter MTS	0.01%	0.04%	0.03%	98%	97%	0.01%	0.10%	0.53%	99%	98%

# CE6-1 Primary Transform

- Fast DST-7/DCT-8
  - CE6-1.1c
    - Fast DST-7/DCT-8 based on DFT
  - CE6-1.4
    - Fast DST-7/DCT-8 based on features of DST-7/DCT-8, only 3 unique elements are adjusted by 1
  - CE6-1.6
    - Fast DST-7/DCT-8 based on DCT-2/DST-2 plus adjustment stage


# CE6-1 Primary Transform

- CE6-1.1c



# CE6-1 Primary Transform

- CE6-1.4



{	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	}
{	c	f	i	l	o	o	l	i	f	c	0	-c	-f	-i	-l	-o	}
{	e	j	o	m	h	c	-b	-g	-l	-p	-k	-f	-a	d	i	n	}
{	g	n	l	e	-b	-i	-p	-j	-c	d	k	o	h	a	-f	-m	}
{	i	o	f	-c	-l	-l	-c	f	o	i	0	-i	-o	-f	c	l	}
{	k	k	0	-k	-k	0	k	k	0	-k	-k	0	k	k	0	-k	}
{	m	g	-f	-n	-a	l	h	-e	-o	-b	k	i	-d	-p	-c	j	}
{	o	c	-l	-f	i	i	-f	-l	c	o	0	-o	-c	l	f	-i	}
{	p	-a	-o	b	n	-c	-m	d	l	-e	-k	f	j	-g	-i	h	}
{	n	-e	-i	j	d	-o	a	m	-f	-h	k	c	-p	b	l	-g	}
{	l	-i	-c	o	-f	-f	o	-c	-i	l	0	-l	i	c	-o	f	}
{	j	-m	c	g	-p	f	d	-n	i	a	-k	l	-b	-h	o	-e	}
{	h	-p	i	-a	-g	o	-j	b	f	-n	k	-c	-e	m	-l	d	}
{	f	-l	o	-i	c	c	-i	o	-l	f	0	-f	l	-o	i	-c	}
{	d	-h	l	-p	m	-i	e	-a	-c	g	-k	o	-n	j	-f	b	}
{	b	-d	f	-h	j	-l	n	-p	o	-m	k	-i	g	-e	c	-a	}

$$\begin{array}{rcl} a + j & = & l \\ b + i & = & m \\ c + h & = & n \\ d + g & = & o \\ e + f & = & p \end{array}$$

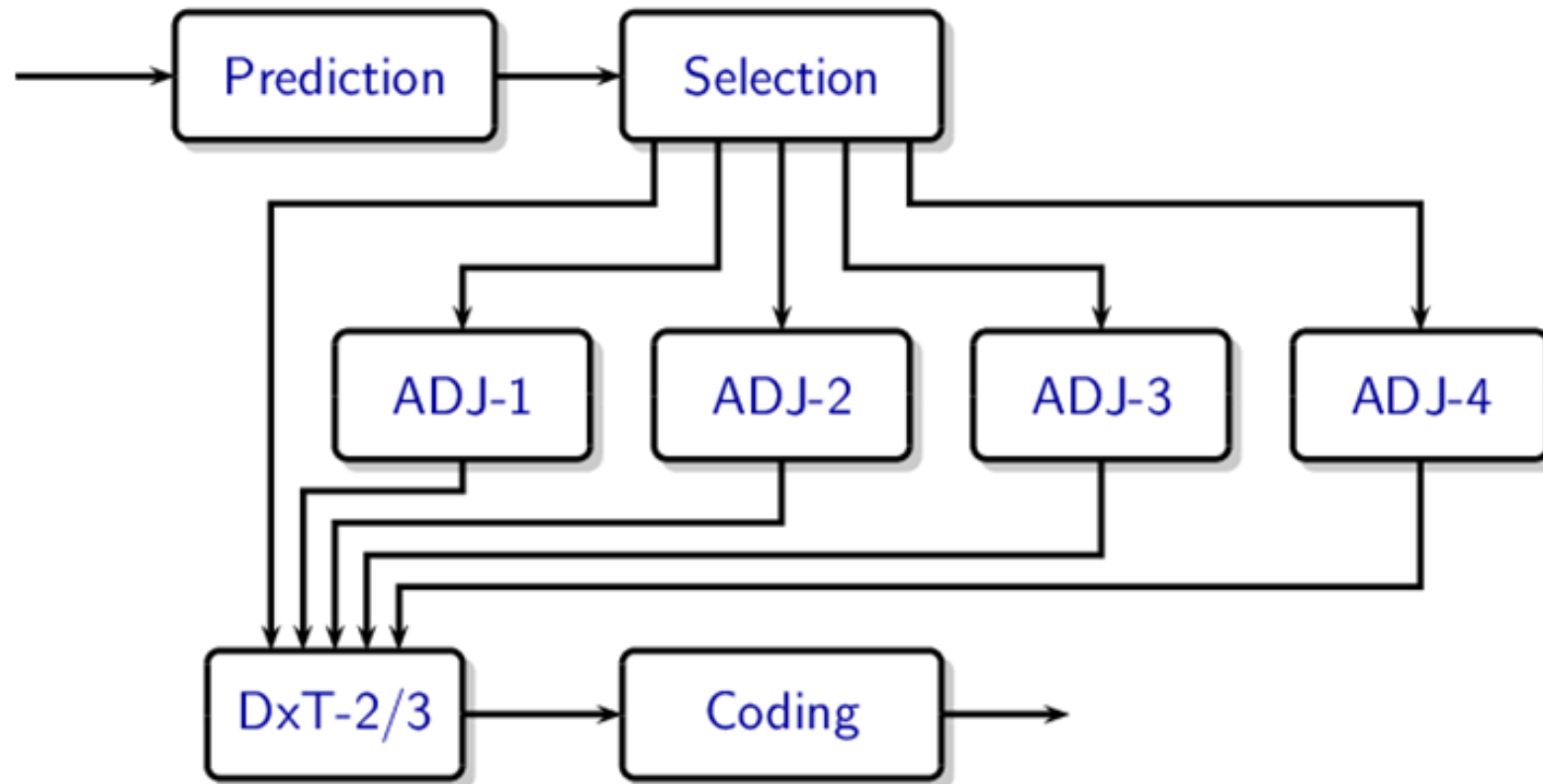
$$y_0 = a \cdot x_0 + j \cdot x_9 + \dots + l \cdot x_{11}$$



$$y_0 = a \cdot (x_0 + x_{11}) + j \cdot (x_9 + x_{11})$$

# CE6-1 Primary Transform

- CE6-1.6



# CE6-1 Primary Transform

- Fast 16-point and 32-point DST-7/DCT-8

Test #	Test Condition	All Intra					Random Access					Low Delay B				
		Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1.1c	CTC	0.01%	0.00%	0.03%	97%	90%	0.01%	0.03%	0.04%	99%	99%	-0.01%	-0.06%	0.01%	99%	100%
CE6-1.4a	CTC	-0.01%	0.01%	0.04%	95%	89%	0.00%	0.03%	0.04%	98%	98%	-0.04%	-0.18%	-0.31%	98%	98%
CE6-1.6a	CTC	0.03%	0.01%	0.06%	98%	90%	0.02%	0.02%	0.09%	99%	98%	0.02%	-0.07%	0.08%	100%	99%
CE6-1.6b	CTC	0.06%	0.04%	0.07%	97%	88%	0.05%	0.05%	0.07%	99%	98%	-0.02%	-0.07%	-0.08%	99%	100%
CE6-1.1c	CTC + Inter MTS	0.01%	0.00%	0.03%	97%	90%	0.00%	-0.06%	0.05%	97%	97%	0.00%	0.04%	0.25%	97%	96%
CE6-1.4a	CTC + Inter MTS	-0.01%	0.01%	0.04%	95%	89%	0.00%	-0.03%	0.07%	96%	97%	-0.01%	-0.12%	0.02%	97%	97%
CE6-1.6a	CTC + Inter MTS	0.03%	0.01%	0.06%	98%	90%	0.01%	-0.05%	0.03%	97%	96%	-0.01%	-0.21%	0.46%	97%	95%
CE6-1.6b	CTC + Inter MTS	0.06%	0.04%	0.07%	97%	88%	0.03%	0.03%	0.06%	96%	96%	0.00%	0.00%	0.05%	96%	96%

16-point DST-7/DCT-8

Test #	Mult	Add	Shift	Stages
CE6-1.1c	83	137	47	2
CE6-1.4a	127	155	16	1
CE6-1.6a	182	210	34	2
CE6-1.6b	160	203	34	2

32-point DST-7/DCT-8

Test #	Mult	Add	Shift	Stages
CE6-1.1c	236	378	88	2
CE6-1.4a	620	718	32	1
CE6-1.6a	534	594	66	2
CE6-1.6b	470	587	66	2



# CE6-1 Primary Transform

- Fast MTS

Test #	Description
6.1.1-a*	Using 2 MTS candidates for Angular mode and 3 candidates for non-angular mode. Here, non-angular mode indicates DC and Planar modes
6.1.1-b*	Using 1 MTS candidate for all modes. Here, 1 MTS candidate indicates DST7
6.1.1-d	a method to zero-out high frequency component for larger transform (i.e., 32x32)

\*Contain CE description modification after T3

# CE6-1 Primary Transform

- Fast MTS

Test #	Test Condition	All Intra					Random Access					Low Delay B				
		Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1.1a*	CTC	0.11%	0.21%	0.22%	78%	99%	0.06%	0.09%	0.12%	96%	100%	-0.05%	0.01%	0.10%	97%	101%
CE6-1.1b*	CTC	0.34%	-0.18%	-0.16%	62%	98%	0.15%	-0.12%	-0.08%	91%	100%	0.02%	-0.15%	-0.25%	96%	100%
CE6-1.1d	CTC	0.11%	0.01%	0.01%	98%	95%	0.03%	0.02%	0.02%	99%	100%	0.02%	0.04%	-0.14%	100%	101%
CE6-1.1a*	CTC + Inter MTS						0.04%	0.08%	0.15%	96%	100%	-0.02%	-0.06%	0.21%	99%	100%
CE6-1.1b*	CTC + Inter MTS						0.14%	-0.21%	-0.06%	93%	100%	0.03%	-0.14%	0.20%	97%	100%
CE6-1.1d	CTC + Inter MTS						0.04%	-0.02%	-0.01%	96%	98%	0.03%	0.07%	-0.05%	96%	98%

# CE6-1 Primary Transform

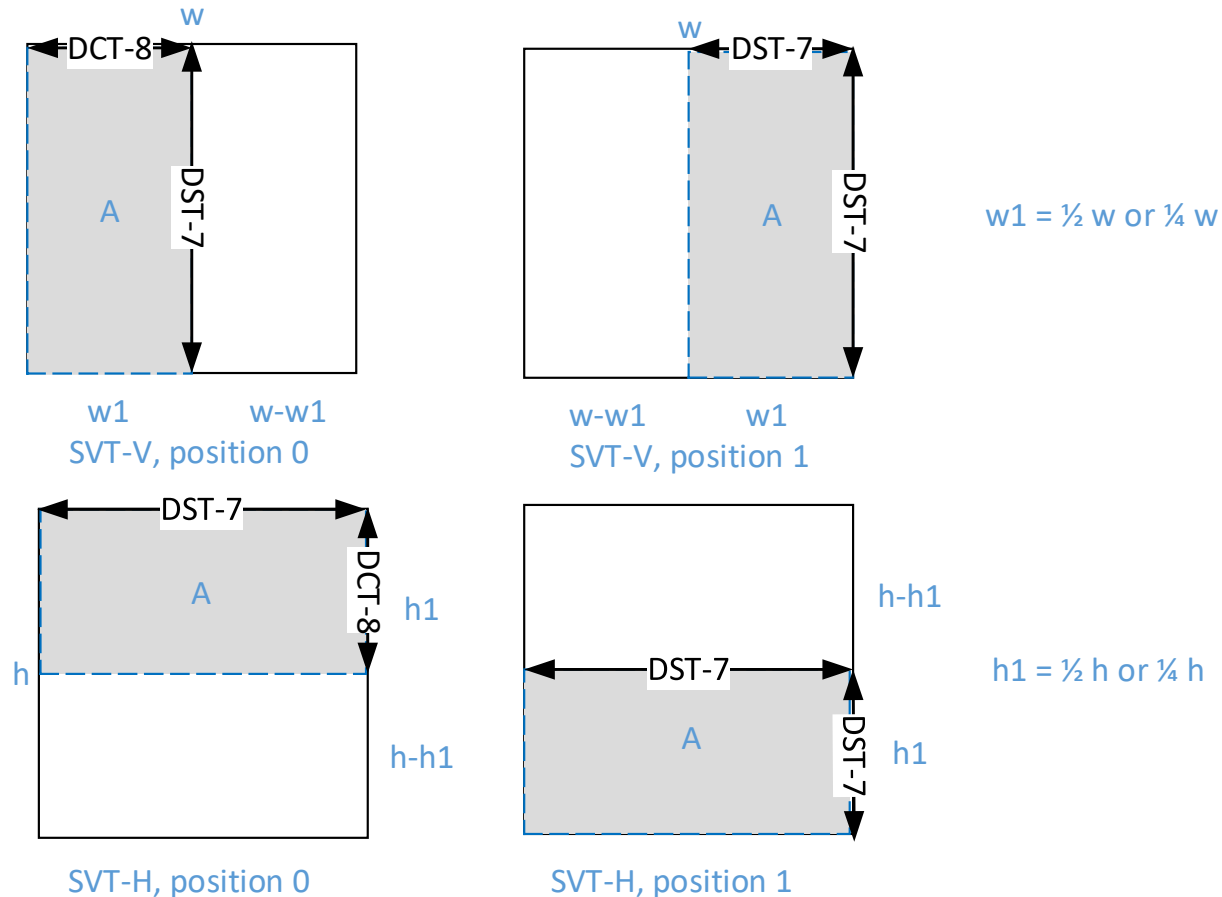
- Sub-block transform

Test #	Description
6.1.2-a*	Normatively enable SVT for inter blocks predict by Merge mode with merge idx 0/1 or by AMVP mode with 1/4-pel MVD precision (i.e., imv=0) or by AFFINE mode
6.1.2-b*	Normatively enable SVT for all inter blocks

\*Contain CE description modification after T3

# CE6-1 Primary Transform

- Sub-block transform



# CE6-1 Primary Transform

- Sub-block transform

Test #	Test Condition	Random Access					Low Delay B				
		Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1.2a	CTC	-0.48%	0.21%	0.03%	109%	102%	-0.94%	-0.06%	-0.10%	114%	104%
CE6-1.2b	CTC	-0.61%	0.20%	0.00%	114%	102%	-1.02%	-0.04%	0.03%	122%	104%
CE6-1.2a	CTC + Inter MTS	-0.37%	0.03%	-0.04%	107%	101%	-0.60%	-0.30%	-0.12%	110%	100%
CE6-1.2b	CTC + Inter MTS	-0.45%	0.07%	-0.03%	110%	100%	-0.65%	-0.32%	-0.03%	114%	100%

# CE6-1 Primary Transform

- More flexible MTS

Test #	Description
6.1.7-d	MTS intra: DST-7 / DCT-8 / DST-2 / DCT-2 MTS inter: DCT-8 / DST-7 Max MTS size: 32
6.1.7-e	MTS intra: DST-4 / DCT-4 / DST-2 / DCT-2 MTS inter: DCT-4 / DST-4 Max MTS size: 32

Test #	Description
6.1.8-a	DCT-II is included in MTS together with a lookup table
6.1.8-b	6-1.8-a using only DCT-II, DST-IV and DCT-VIII

# CE6-1 Primary Transform

- Sub-block transform

Test #	Test Condition	All Intra					Random Access					Low Delay B				
		Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1.7d	CTC	-0.21%	-0.18%	-0.15%	97%	95%	-0.07%	0.00%	0.02%	97%	97%	-0.10%	0.13%	-0.29%	96%	95%
CE6-1.7e	CTC	0.08%	0.02%	0.06%	98%	93%	0.11%	0.17%	0.14%	97%	97%	-0.01%	-0.24%	-0.15%	96%	95%
CE6-1.8a	CTC	-0.05%	0.09%	0.11%	101%	100%	-0.02%	0.09%	0.06%	100%	100%	-0.04%	0.05%	-0.27%	101%	101%
CE6-1.8b	CTC	0.03%	0.14%	0.14%	101%	98%	0.08%	0.16%	0.22%	100%	101%	-0.03%	-0.03%	-0.01%	100%	99%
CE6-1.7d	CTC + Inter MTS	-0.21%	-0.18%	-0.15%	97%	95%	-0.08%	-0.04%	0.01%	98%	97%	-0.08%	0.20%	0.09%	99%	98%
CE6-1.7e	CTC + Inter MTS	0.08%	0.02%	0.06%	98%	93%	0.07%	0.01%	0.06%	100%	96%	-0.22%	-0.22%	-0.14%	100%	98%
CE6-1.8a	CTC + Inter MTS						-0.01%	0.01%	0.05%							
CE6-1.8b	CTC + Inter MTS						0.05%	0.02%	0.09%							

# CE6-1 Primary Transform

- Enabling 64-point MTS

Test #	Description	Tester	Cross-checker
6.1.6-c	Efficient Implementations of MTS with Transform Adjustment Stages (Max. MTS size = 64)	Qualcomm	B<>com

Test #	Test Condition	All Intra					Random Access					Low Delay B				
		Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-1.6c	CTC	-0.02%	-0.06%	-0.06%	98%	91%	-0.07%	-0.26%	-0.23%	101%	98%	-0.05%	-0.23%	-0.47%	101%	101%
CE6-1.6c	CTC w/ Inter MTS	-0.02%	-0.06%	-0.06%	98%	90%	-0.14%	-0.19%	-0.19%	104%	96%	-0.18%	-0.03%	-0.35%	104%	95%



# CE6-2 Secondary Transform

- Coding efficiency
  - CE6-2.1 a/b/c/d
    - Reduced Size Transform, only keep first 16 coefficients for 8x8 NSST
    - Reduced candidates of MTS, only keep {DST-7, DST-7}, MTS index removed
    - Worst case handling, reduce multiplications per sample
    - Reduced memory size, total 8 4x4 NSST cores, 8 8x8 NSST cores
    - NSST selection depends on MTS flag
  - CE6-2.3 a/b:
    - NSST based on explicit signaling, flag and index

# CE6-2 Secondary Transform

	All Intra					Random Access					Low Delay B				
Test #	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-2.1a	-1.00%	-2.00%	-2.36%	96%	96%	-0.55%	-1.50%	-1.81%	101%	100%	-0.24%	-0.79%	-1.15%	101%	101%
CE6-2.1b	-1.58%	-2.41%	-2.81%	95%	97%	-0.89%	-1.62%	-2.05%	102%	101%	-0.38%	-1.02%	-1.22%	102%	101%
CE6-2.1c	-1.16%	-1.86%	-2.21%	124%	98%	-0.61%	-1.38%	-1.71%	109%	100%	-0.30%	-0.69%	-1.25%	105%	100%
CE6-2.1d	-1.75%	-2.40%	-2.77%	121%	96%	-0.93%	-1.65%	-2.11%	109%	99%	-0.43%	-0.89%	-1.28%	104%	100%
CE6-2.2a	-0.60%	-1.70%	-2.40%	371%	100%	-0.40%	-1.60%	-2.20%	177%	101%	-0.20%	-0.70%	-1.30%	137%	100%
CE6-2.2d	-1.80%	-2.60%	-3.20%	383%	103%	-1.00%	-2.20%	-2.60%	185%	101%	-0.40%	-1.30%	-1.70%	143%	100%

# CE6-3 Combination & Signaling

- Coding efficiency

- CE6-3.1 b/c
  - NSST selection coupled with MTS index
  - MTS selection specified by a new block-size dependent LUT
  - 4x4 NSST based on HyGT, 8x8 NSST based on HSMT
- CE6-3.2 a/b/c
  - NSST selection coupled with MTS index
  - MTS index signaling modified from 2-bit fix-length to TUC
  - Matrix multiplication based NSST, only 4x4 proposed
- CE6-3.3 a/b
  - MTS only use {DST-7, DST-7}
  - NSST selection coupled with MTS index
  - 8x8 NSST based on HSMT

# CE6-2/3 summary

						All Intra					Random Access					Low Delay B				
Test #	Change to primary transform	Memory (KB)	Mult. Per pixel	Pass/round	8x8 NSST	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT	Y	U	V	EncT	DecT
CE6-2.1a	1 cand. (DST-7, DST-7)	10	8	1	Y	-1.00%	-2.00%	-2.36%	96%	96%	-0.55%	-1.50%	-1.81%	101%	100%	-0.24%	-0.79%	-1.15%	101%	101%
CE6-2.1b	2 cand. for Ang. else 3 cand.	5	8	1	Y	-1.16%	-1.86%	-2.21%	124%	98%	-0.61%	-1.38%	-1.71%	109%	100%	-0.30%	-0.69%	-1.25%	105%	100%
CE6-2.1c	1 cand. (DST-7, DST-7)	128.75	16	1	Y	-1.58%	-2.41%	-2.81%	95%	97%	-0.89%	-1.62%	-2.05%	102%	101%	-0.38%	-1.02%	-1.22%	102%	101%
CE6-2.1d	2 cand. for Ang. else 3 cand.	128.75	16	1	Y	-1.75%	-2.40%	-2.77%	121%	96%	-0.93%	-1.65%	-2.11%	109%	99%	-0.43%	-0.89%	-1.28%	104%	100%
CE6-2.2a	N/A					-0.60%	-1.70%	-2.40%	371%	100%	-0.40%	-1.60%	-2.20%	177%	101%	-0.20%	-0.70%	-1.30%	137%	100%
CE6-2.2d					Y	-1.80%	-2.60%	-3.20%	383%	103%	-1.00%	-2.20%	-2.60%	185%	101%	-0.40%	-1.30%	-1.70%	143%	100%
CE6-3.1b	A new LUT for MTS selection				Y	-0.75%	-0.54%	-0.55%	97%	101%	-0.36%	-0.15%	-0.26%	99%	101%	-0.23%	-0.01%	-0.27%	101%	103%
CE6-3.1c					Y	-1.67%	-1.03%	-1.04%	97%	100%	-0.95%	-0.27%	-0.29%	99%	100%	-0.45%	-0.40%	-0.45%	100%	102%
CE6-3.2a	mts_idx using TUC	25.75	16	1		-0.46%	-0.39%	-0.37%	100%	101%	-0.23%	-0.10%	-0.10%	100%	100%	-0.13%	-0.09%	-0.57%	99%	100%
CE6-3.2b		25.75	16	1		-0.50%	-0.65%	-0.68%	101%	100%	-0.24%	-0.45%	-0.53%	100%	100%	-0.17%	-0.52%	-0.86%	100%	101%
CE6-3.2c		9.25	16	1		-0.43%	-0.59%	-0.62%	98%	99%	-0.22%	-0.37%	-0.45%	98%	98%	-0.15%	-0.24%	-0.30%	98%	98%
CE6-3.3a	Intra MTS has only one cand.				Y	-0.36%	-0.52%	-0.51%	96%	97%	-0.19%	-0.15%	-0.15%	99%	100%	-0.10%	-0.09%	-0.10%	100%	101%
CE6-3.3b					Y	-1.30%	-0.96%	-1.00%	97%	99%	-0.73%	-0.11%	-0.22%	99%	100%	-0.34%	-0.05%	-0.18%	100%	100%