

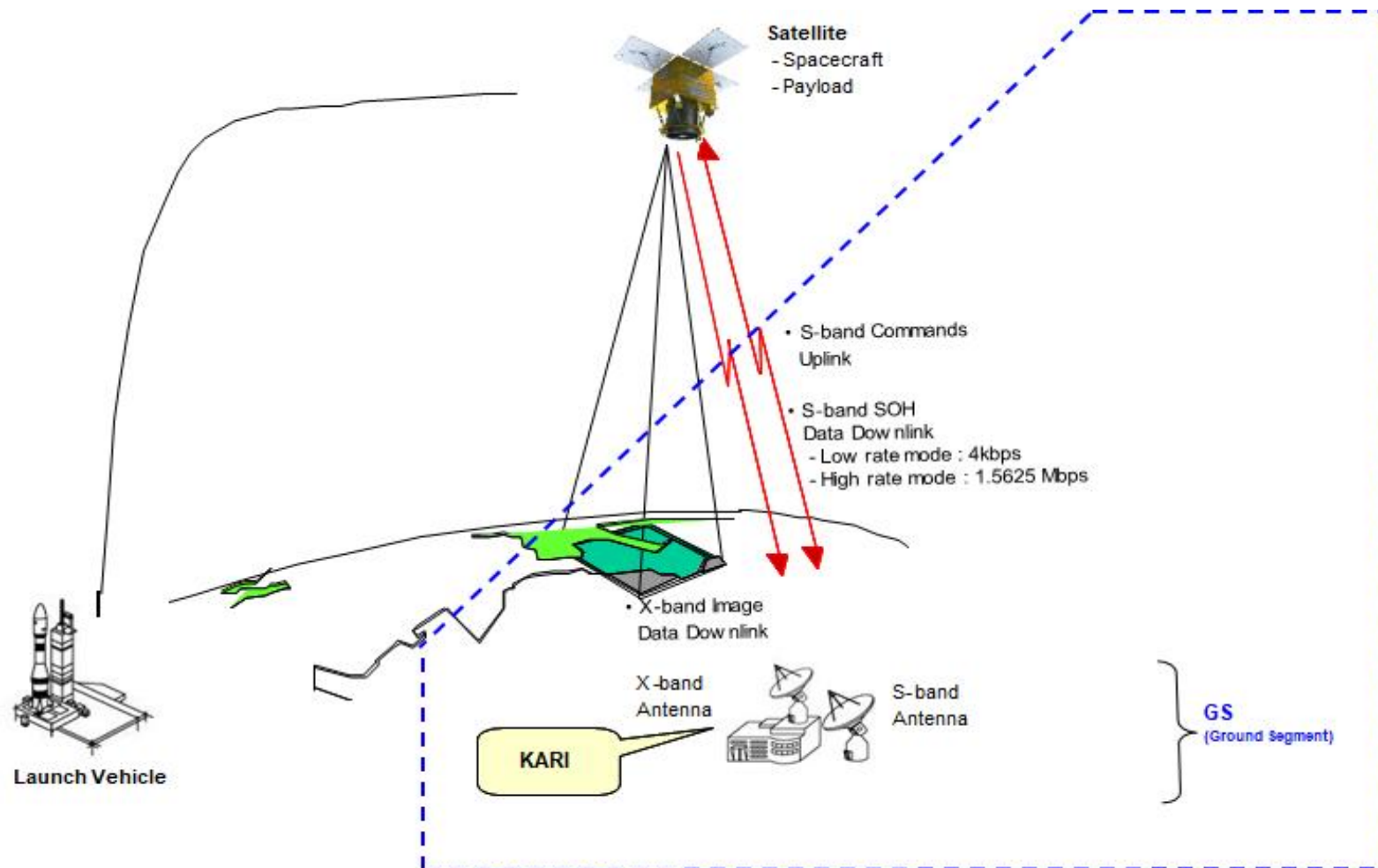
# Ground Segment

구 인 회

2022. 1

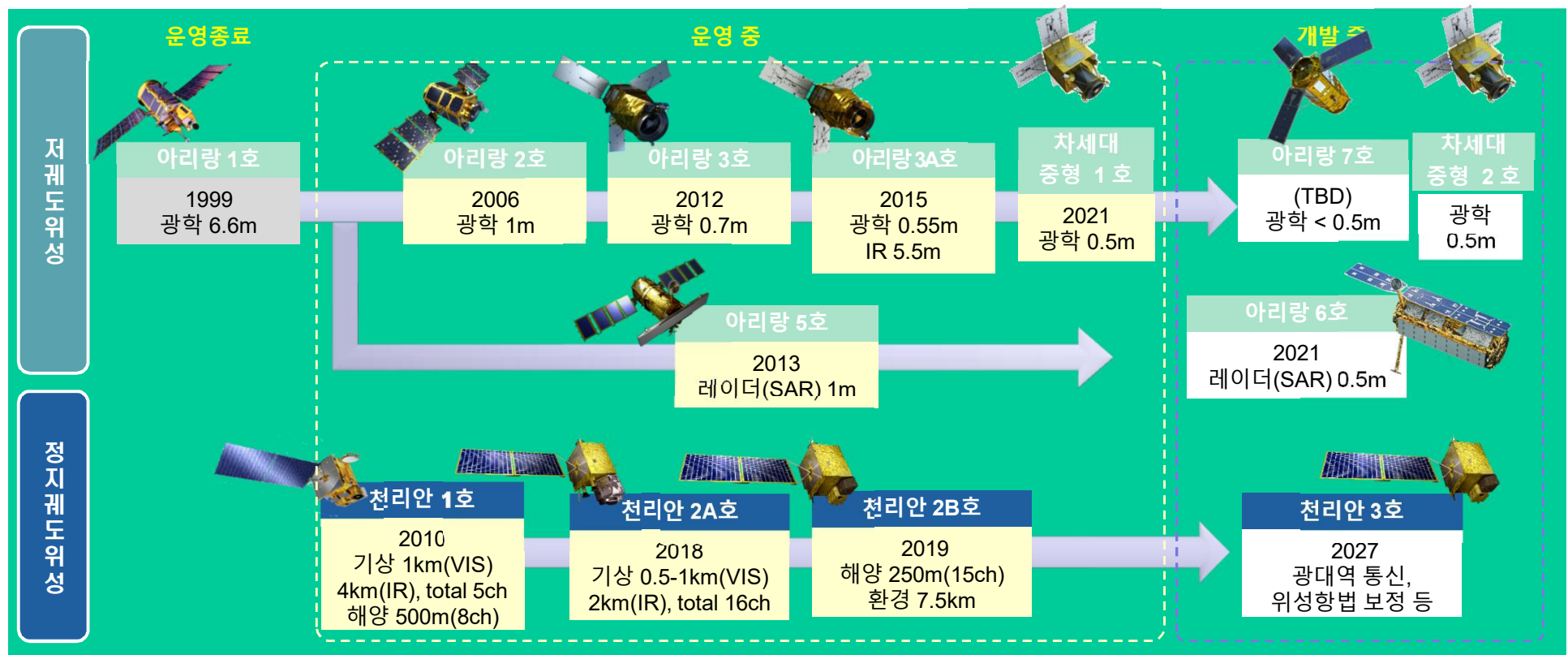
## Ground Segment Overview

# Ground Segment : Overview

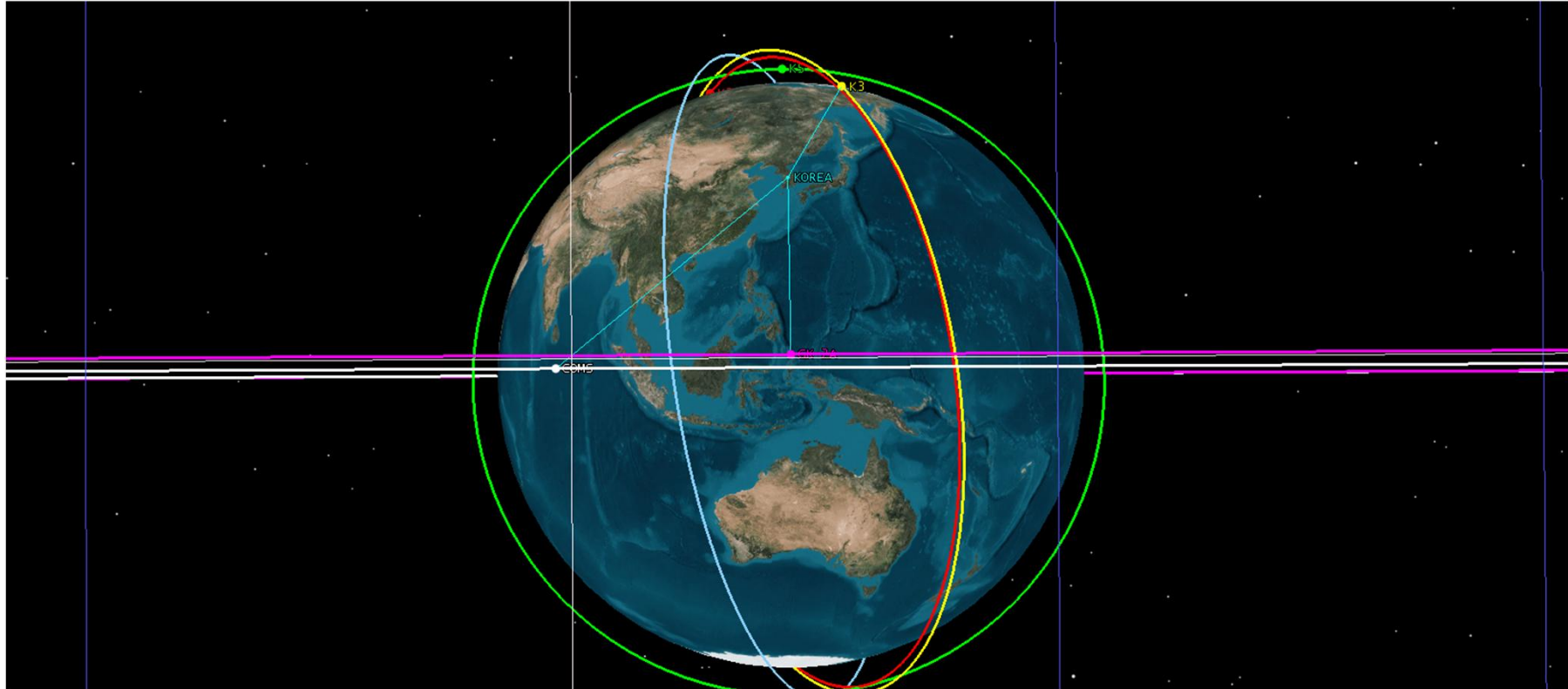


# 한국항공우주연구원 위성 현황

KARI Constellation Satellites(2021. 05. 12. 기준)



# 저궤도 위성 vs. 정지궤도 위성



# 위성 임무 운영 절차

## 촬영요청에서 영상전달까지

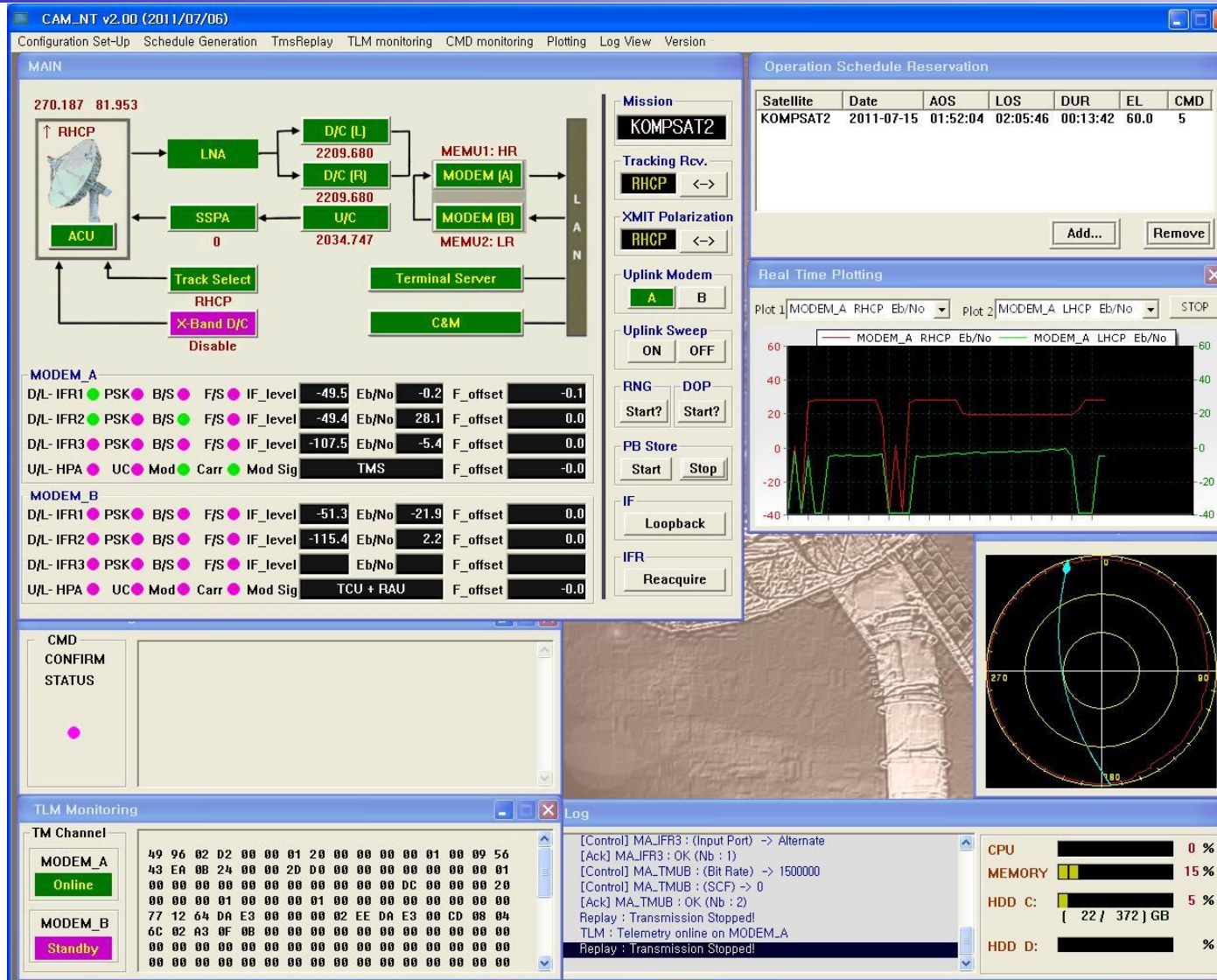


## TTC Operation

- 하나의 안테나로 여러 위성을 운영하기 위해서는 위성과의 교신 전 위성의 특성에 맞게 TTC 장비들의 파라미터를 설정해주어야 함.
- TTC 장비의 Control & Monitoring 은 C&M 소프트웨어를 통해 원격으로 수행
- TTC C&M S/W 의 또다른 기능은 위성의 TLE (Two Line Element)를 이용하여, 위성의 교신 스케줄을 생성하고, 스케줄 예약을 통해 장비 초기화 및 여러 기능을 자동 수행함.



# TTC 원격 감시제어 소프트웨어



## Telemetry Processing

# S-Band Telemetry Format

## ➤ S-Band Telemetry Format

- ✓ The S-band telemetry format is designed to follow CCSDS Grade-2 standards
- ✓ A Channel Access Data Unit (CADU) contains 256 bytes

Channel Access Data Unit (CADU) format

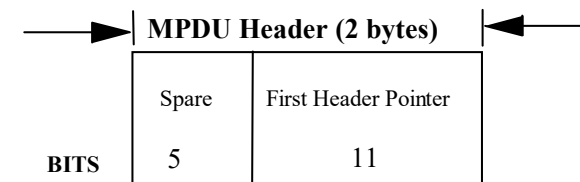
	SYNC Word	VCDU Primary Header	MPDU Header	VCDU Data	R-S Check Symbols	SYNC Word	VCDU Primary Header	MPDU Header	...
BYTES	4	6	2	212	32	4	6	2	

- Sync Word : 1A CF FC 1D (4bytes)

- VCDU Primary Header Values (6bytes)

Bits	Field	Value
2	Transfer Frame Version Number	01b (AOS – grade 2)
8	Spacecraft ID	
6	Virtual Channel ID	
24	Virtual Channel Data Unit Count	Counter
1	Relay Flag	0 = Real time VCDU, 1 = Playback VCDU
7	Spare	0d

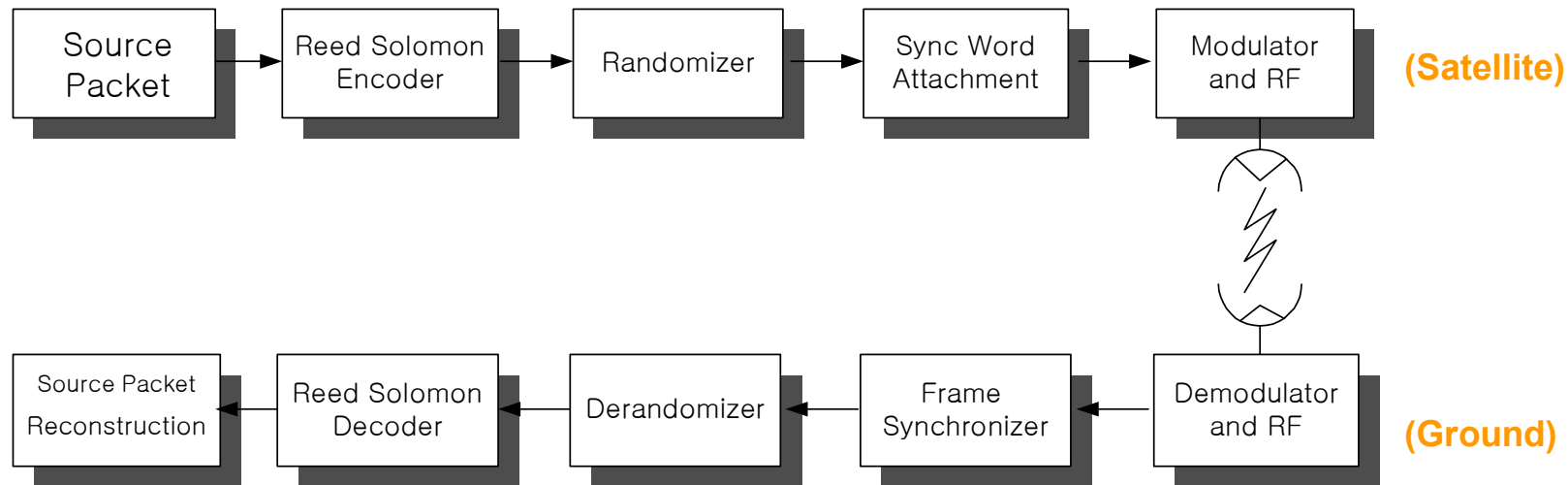
- MPDU Header (2bytes)



➔ MPDU Header 에는 Packet 의 시작 위치 정보

# Telemetry Processing

## ➤ Concatenated Coding System Block Diagram



## ➤ Telemetry Processing 순서

1. Bit synchronization
2. Frame synchronization
3. De-Randomizing
4. RS-Decoding
5. Packet Reconstruction
6. Raw value → Engineering Value (using Telemetry Data Base, Calibration Curve information)

# Frame Synchronization

## ➤ Frame Sync Word 의 다양한 형태

			1	A	C	F	F	C	1	D	B	D
original			0001	1010	1100	1111	1111	1100	0001	1101	1011	1101
			3	5	9	F	F	8	3	B	8	
1bit offset		0	0011	0101	1001	1111	1111	1000	0011	1011	0111	101
			6	B	3	F	F	0	7	6	0	
2bit offset		00	0110	1011	0011	1111	1111	0000	0111	0110	1111	01
			D	6	7	F	E	0	E	D	1	
3bit offset		000	1101	0110	0111	1111	1110	0000	1110	1101	1110	1
		1	A	C	F	F	C	1	D	B	2	
4bit offset		0001	1010	1100	1111	1111	1100	0001	1101	1011	1101	
		3	5	9	F	F	8	3	B	7		
5bit offset	0	0011	0101	1001	1111	1111	1000	0011	1011	0111	101	
		6	B	3	F	F	0	7	6	F		
6bit offset	00	0110	1011	0011	1111	1111	0000	0111	0110	1111	01	
		D	6	7	F	E	0	E	D	E		
7bit offset	000	1101	0110	0111	1111	1110	0000	1110	1101	1110	1	
		A	C	F	F	C	1	D	B	D		
8bit offset	0001	1010	1100	1111	1111	1100	0001	1101	1011	1101		



# Frame Synchronization

## ➤ Raw Data 의 Sync pattern 예시

KSAT, 20040209, 22108, dat

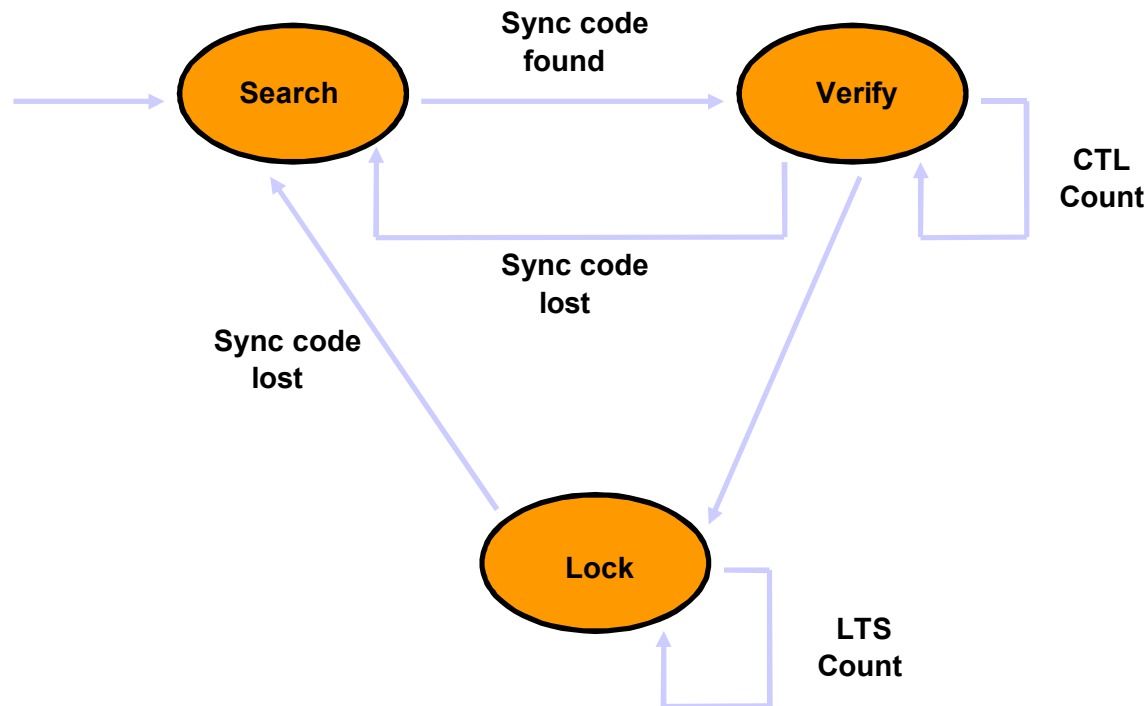
0:	5F	D7	5E	01	00	08	80	00	00	00	11	1F	00	00	00	00
16:	40	26	E8	A0	EF	99	68	00	00	19	58	3B	00	00	00	00
32:	00	00	00	00	00	00	11	1F	00	00	00	00	00	00	00	00
48:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
64:	D1	90	72	EF	10	D7	74	39	43	18	C8	C8	79	56	6E	87
80:	A8	86	6D	62	AB	BA	72	51	10	FE	A9	38	3D	7F	DA	8E
96:	98	A0	A9	92	30	3F	66	00	64	43	87	86	74	1A	D8	3A
112:	83	3E	08	57	F5	86	56	20	E3	CF	F0	C3	38	5C	97	DE
128:	00	02	62	27	32	BD	9E	F2	4A	D5	59	3B	6E	C2	D0	E5
144:	26	7C	40	1E	7B	BD	1D	50	26	EE	F0	87	80	79	B8	BA
160:	90	B4	F3	CE	04	5A	3C	35	14	58	24	D1	D9	B2	95	5F
176:	29	2C	D4	28	A0	BE	5E	E4	C9	99	05	AB	D7	34	E9	1E
192:	89	DF	51	5B	9C	B1	1D	6F	CE	F0	AE	74	A4	54	1D	79
208:	A4	FE	9F	70	10	7D	ED	48	E3	C3	5A	46	BF	28	62	FC
224:	C2	2C	73	35	F8	F0	9B	2E	5B	15	49	7E	8C	AF	BE	37
240:	4C	89	EA	E7	17	EC	BF	57	02	A1	F3	EB	F9	77	E1	2F
256:	B2	7A	E0	69	E4	33	00	2A	B0	5F	64	9C	CF	79	6B	18
272:	0F	85	12	F8	98	CE	DA	6A	71	B4	00	1E	F4	F5	81	A2
288:	4D	AF	47	88	42	25	40	64	74	8E	EB	38	14	05	94	05
304:	CF	59	69	7A	8A	53	77	4C	7C	51	33	01	AC	FF	C1	DB
320:	D3	70	EC	09	A0	D7	0B	C8	E2	C9	3A	DA	7B	74	6C	E5
336:	A9	77	DC	C3	2A	2B	F3	E0	A1	0F	18	89	4C	DE	AB	1F
352:	E9	01	D8	13	41	AE	17	91	C5	92	75	B4	F6	E8	D9	CB
368:	52	EF	B9	86	54	57	E7	C1	42	1E	31	12	99	BD	56	3F
384:	D2	03	B0	26	83	5C	2F	23	8B	24	EB	69	ED	D1	B3	96
400:	A5	DF	73	0C	A8	AF	CF	82	84	3C	62	25	33	7A	AC	7F
416:	A4	07	60	4D	06	B8	5E	47	16	49	D6	D3	DB	A3	67	2D
432:	4B	BE	E6	19	51	5F	9F	05	08	78	C4	4A	66	F5	58	FF
448:	48	0E	C0	9A	0D	70	BC	8E	2C	93	AD	A7	B7	46	CE	5A
464:	97	7D	CC	32	A2	BF	3E	0A	10	F1	88	94	CD	EA	B1	FE
480:	90	1D	81	34	1A	E1	79	1C	59	27	58	4F	6E	8D	9C	B5
496:	2E	FB	98	65	45	7E	7C	14	21	E3	11	29	9B	D5	63	FD
512:	20	3B	02	68	35	C2	F2	38	B2	4E	B6	9E	DD	1B	39	6A
528:	5D	F7	30	CA	8A	FC	F8	28	43	C6	22	53	03	A7	0A	25
544:	7B	37	B1	86	8F	3E	91	0C	C1	F0	23	60	56	3C	1F	B6
560:	A5	3E	3D	32	95	93	70	1A	8C	FB	6B	E1	AC	FF	C1	DB
576:	D1	90	72	EF	60	D7	74	3A	D0	AB	08	B8	49	D7	2F	47
592:	5B	85	7E	71	58	B9	81	22	33	5D	0A	BB	5E	9C	99	4D
608:	BB	B3	BA	41	63	FF	F5	90	27	93	84	45	27	09	08	2A

KSAT, 20050926, 30833, dat

0:	5F	D7	5E	01	00	08	80	00	00	00	0A	AD	00	00	00	00
16:	43	38	08	13	63	66	0F	00	00	19	59	2D	00	00	00	00
32:	00	00	00	00	00	00	0A	AD	00	00	00	00	00	00	00	00
48:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
64:	6E	8D	9C	B5	2E	FB	98	65	45	7E	7C	14	21	E3	11	29
80:	9B	D5	63	FD	20	3B	02	68	35	C2	F2	38	B2	4E	B6	9E
96:	DD	1B	39	6A	5D	F7	30	CA	8A	FC	F8	28	43	C6	22	53
112:	37	AA	C7	FA	40	76	04	D0	6B	85	E4	71	64	9D	6D	3D
128:	BA	36	72	D4	BB	EE	61	95	15	F9	F0	50	87	8C	44	BC
144:	07	4E	14	4A	F6	6F	63	0D	1E	7D	22	19	83	E0	46	C0
160:	AC	78	3F	6D	4A	7C	7A	65	2B	26	E0	35	19	F6	D7	C3
176:	59	FF	83	B7	A6	E1	D8	13	41	AE	17	91	C5	92	75	B4
192:	F6	E8	D9	CB	52	EF	B9	86	54	57	E7	C1	42	1E	31	12
208:	99	BD	56	3F	D2	03	B0	26	83	5C	2F	23	8B	24	EB	69
224:	ED	D1	B3	96	A5	DF	73	0C	A8	AF	CF	82	84	3C	62	25
240:	33	7A	AC	7F	A4	07	60	4D	06	B8	5E	47	16	49	D6	D3
256:	DB	A3	67	2D	4B	BE	E6	19	51	5F	9F	05	08	78	C4	4A
272:	66	F5	58	FF	48	0E	C0	9A	0D	70	BC	8E	2C	93	AD	A7
288:	B7	46	CE	5A	97	7D	CC	32	A2	BF	3E	0A	10	F1	88	94
304:	CD	EA	B1	FE	90	1D	81	34	1A	E1	79	1C	59	27	5B	4F
320:	6E	8D	9C	B5	2E	FB	98	65	45	7E	7C	14	21	E3	11	29
336:	9B	D5	63	FD	20	3B	02	68	35	C2	F2	38	B2	4E	B6	9E
352:	DD	1B	39	6A	5D	F7	30	CA	8A	FC	F8	28	43	C6	22	53
368:	37	AA	C7	FA	40	76	04	D0	6B	85	E4	71	64	9D	6D	3D
384:	BA	36	72	D4	BB	EE	61	95	15	F9	F0	50	87	8C	44	BC
400:	07	4E	14	4A	F6	6F	63	0D	1E	7D	22	19	83	E0	46	C0
416:	AC	78	3F	6D	4A	7C	7A	65	2B	26	E0	35	19	F6	D7	C3
432:	59	FF	83	B7	A6	E1	D8	13	41	AE	17	91	C5	92	75	B4
448:	F6	E8	D9	CB	52	EF	B9	86	54	57	E7	C1	42	1E	31	12
464:	99	BD	56	3F	D2	03	B0	26	83	5C	2F	23	8B	24	EB	69
480:	ED	D1	B3	96	A5	DF	73	0C	A8	AF	CF	82	84	3C	62	25
496:	33	7A	AC	7F	A4	07	60	4D	06	B8	5E	47	16	49	D6	D3
512:	DB	A3	67	2D	4B	BE	E6	19	51	5F	9F	05	08	78	C4	4A
528:	66	F5	58	FF	48	0E	C0	9A	0D	70	BC	8E	2C	93	AD	A7
544:	B7	46	CE	5A	97	7D	CC	32	A2	BF	3E	0A	10	F1	88	94
560:	CD	EA	B1	FE	90	1D	81	34	1A	E1	79	1C	59	27	5B	4F
576:	6E	8D	9C	B5	2E	FB	98	65	45	7E	7C	14	21	E3	11	29
592:	9B	D5	63	FD	20	3B	02	68	35	C2	F2	38	B2	4E	B6	9E
608:	DD	1B	39	6A	5D	F7	30	CA	8A	FC	F8	28	43	C6	22	53

# Frame Synchronization

## ➤ Sequence of Frame Synchronization



- Frame Sync. 관련 Cortex 설정

SYNC	CTL	LTS	SLIP
1	1	1	0

### • SYNC

- sync code 중 일치하지 않은 bit의 한계치를 말하며 예를 들어 2라고 설정하면 2bits 까지는 틀리더라도 sync code를 찾은 것으로 간주함.  
Maximum = 8 bits

### • CTL (Check to Lock)

- Verify 횟수를 의미하며 연속해서 Verify count 동안 계속 일치하면 Lock 상태로 이동함.

### • LTS (Lock to Search)

- Lock 상태에서 연속해서 LTS count 동안 sync code가 불일치하면 Search 단계로 이동함.

### • SLIP

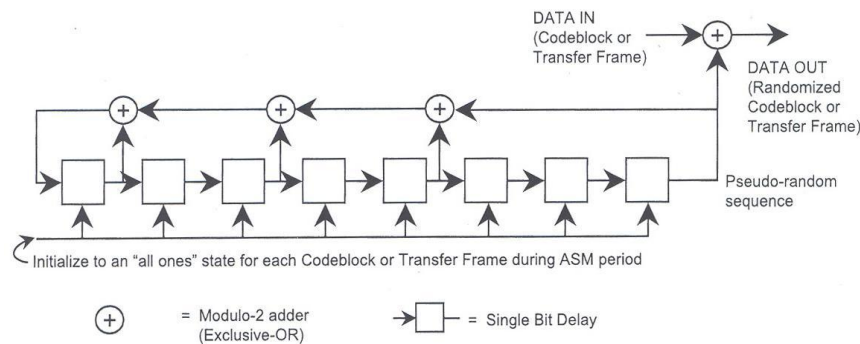
- 송신 및 수신장치의 각 클럭 속도 차이에서 발생하는 비트의 손실 및 추가.

# De-Randomizing Theory

## ➤ Randomizing?

- ✓ 위성에서 데이터를 최종적으로 전송하기에 앞서 지상 장비가 수신된 신호에 대해 **Bit sync**를 유지할 수 있도록 데이터에 **pseudo noise**를 섞어서 전송 (같은 비트가 연속인 경우, 지상장비에서 비트 동기화 불가능)
- ✓ **Randomizing**은 전송할 데이터의 각 **bit**들과 **Randomizer**에서 생성된 **Random code**의 각 **bit**들간에 **XORing** 시킴으로써 수행된다.

## ➤ Pseudo-Randomizer



## ➤ Pseudo-Random code (255bytes)

DeRandomcode_255.dat																	
0:	FE	48	0E	CC	9A	0D	70	BC	8E	2C	93	AD	A7	B7	46	CE	H.....p.....F.
16:	5A	97	7D	CC	32	A2	BF	3E	0A	10	F1	88	94	CD	EA	B1	Z...2...>.....
32:	FE	90	1D	81	34	1A	E1	79	1C	59	27	5B	4F	6E	8D	9C	...4...y.Y'[On..
48:	B5	2E	FB	98	65	45	7E	7C	14	21	E3	11	29	9B	D5	63	...eE~ .l...).c
64:	FD	20	3B	02	68	35	C2	F2	38	B2	4E	B6	9E	DD	1B	39	...h5..8.N...9
80:	6A	5D	F7	30	CA	8A	FC	F8	28	43	C6	22	53	37	AA	C7	j].0....(C."S7..
96:	FA	40	76	04	D0	6B	85	E4	71	64	9D	6D	3D	BA	36	72	..@v..k..gd.m=.6r
112:	D4	BB	EE	61	95	15	F9	F0	50	87	8C	44	A6	6F	55	8F	...a....P...D.oU
128:	F4	80	EC	09	A0	D7	0B	C8	E2	C9	3A	DA	7B	74	6C	E5	.....{t1.
144:	A9	77	DC	C3	2A	2B	F3	E0	A1	0F	18	89	4C	DE	AB	1F	.w...*+.....L...
160:	E9	01	D8	13	41	AE	17	91	C5	92	75	B4	F6	E8	D9	CB	...A.....u.....
176:	52	EF	B9	86	54	57	E7	C1	42	1E	31	12	99	BD	56	3F	R...TW...B.1...V?
192:	D2	03	B0	26	83	5C	2F	23	8B	24	EB	69	ED	D1	B3	96	...&.\/#.\$..i....
208:	A5	DF	73	0C	A8	AF	CF	82	84	3C	62	25	33	7A	AC	7F	..s.....<b%3z...
224:	A4	07	60	4D	06	B8	5E	47	16	49	D6	D3	DB	A3	67	2D	..`M...^G.I....g-
240:	4B	BE	E6	19	51	5F	9F	05	08	78	C4	4A	66	F5	58		R...Q...x.Jf.X

- ✓ Pseudo-random generator polynomial =  $x^8 + x^7 + x^5 + x^3 + 1$
- ✓ First 40bits of the pseudo-random sequence are :  
**1111 1111 0100 1000 0000 1110 1100 0000 1001 1010 ...**
- ✓ Pseudo-random code 는 255bit 마다 반복된다. (반복주기:  $2^N-1$  bits)
- ✓ 지상에서는 Sync word를 제외한 데이터에 대해 위의 Pseudo-Random code 와 XORing 시킨다.  
 (= De-randomizing = De-scrambling)



# De-randomizing Example

Before DeRandomizing

```

KSAT_20040209_22108_synced.dat
0: 1A CF FC 1D BD 37 0E C0 9A 0D 70 BC 8E 2C 93 AD .....7...p....
16: A7 B7 46 CE 5A 97 7D CC 32 A2 BF 3E 0A 10 F1 88 ..F.Z.}.2..>....
32: 94 CD EA B1 FE 90 1D 81 34 1A E1 79 1C 59 27 5B .....4..y.Y'[
48: 4F 6E 8D 9C B5 2E FB 98 65 45 7E 7C 14 21 E3 11 On....eE~|.!.
64: 29 9B D5 63 FD 20 3B 02 68 35 C2 F2 38 B2 4E B6 )..c. ;h5..8.N.
80: 9E DD 1B 39 6A 5D F7 30 CA 8A FC F8 28 43 C6 22 ...9j].0....(C."
96: 53 37 AA C7 FA 40 76 04 D0 6B 85 E4 71 64 9D 6D S7...v..k..gd.m
112: 3D BA 36 72 D4 BB EE 61 95 15 F9 F0 50 87 8C 44 =.6r...a....P..D
128: A6 6F 55 8F F4 80 EC 09 A0 D7 0B C8 E2 C9 3A DA .oU...v...k..gd.m
144: 7B 74 6C E5 A9 77 DC C3 2A 2B F3 E0 A1 0F 18 89 {tl..w...*...u.
160: 4C DE AB 1F E9 01 D8 13 41 AE 17 91 C5 92 75 B4 L...R...A...u.
176: F6 E8 D9 CB 52 FF B9 86 54 57 E7 C1 42 1E 31 12 ....R...TW...B.1.
192: 99 BD 56 3F D2 03 B0 26 83 5C 2F 23 8B 24 EB 69 ..V?..&..#$.i
208: ED D1 B3 96 A5 DF 73 0C A8 AF CF 82 84 3C 62 25 .....<b%
224: E0 3A 70 A2 57 B3 7B 18 68 F3 E9 10 CC 1F 02 36 ..p.W.{.h.....6
240: 05 63 C1 FB 6A 53 E3 D3 29 59 37 01 A8 CF BE BE .c..jS..)Y7....
256: 1A CF FC 1D BD 19 07 2E F6 0D 77 43 AD 0A B0 8B .....wC....
272: 84 9D 72 F4 75 B8 57 E7 15 8B 98 12 23 35 D0 AB ..r..u.W...#5...
288: B5 E9 C9 94 DB BB 3B A4 16 3F FF 59 02 79 38 44 .....?..Y.y8D
304: 52 70 90 62 A9 31 E7 85 7F 5B 63 60 0F 3F F8 0C Rp...l...[c'?.
320: 32 86 CE 7F E7 3B 21 19 72 2E D8 EC 24 AC 55 AB 2....|..r...$.U.
336: 85 C0 D0 27 71 40 EC 2C D0 97 E6 E5 34 5E DD 3F ...'q@...4^..?
352: 4A 2D B2 DE ED 59 6E 1E C7 76 99 FA 6A 7F 84 76 J-...Yn..v..j..v
368: 27 A6 2F 6F CF A4 F3 7F 8E 0B E0 EB 49 9B 97 59 '.../6.....l..Y
384: BD 73 4F 94 ED 9D F0 28 83 F1 2D E1 C6 E3 13 F7 .s0....(.-....
400: 53 5D 44 C9 8C 50 FF E5 0F 07 D5 C6 85 28 3D AE SJD..P.....(=
416: 6F FB 8F 39 C8 24 F9 37 60 8D 37 B1 D8 B1 54 90 o..9$.7^..7...T.
432: D5 CD FA E9 4C CF A5 98 4E 4A FC DE 5F 00 11 35 ....L...NJ...5
448: BF 95 74 1A F6 27 AF 06 9D 43 31 01 AB 06 CB 4E .t..'.C1...N
464: C7 E1 9C A2 97 F0 59 27 8F 86 EB AA A2 1A 40 03 ...Y'.....@.
480: 18 67 3A 42 28 29 89 75 84 D9 85 5E 48 1A F4 56 .g:B(.u...^H..V
496: 3F 73 4B 18 B4 05 70 AE 2B D8 C1 9D FE DA DD 30 ?sK...p.+.....0
512: 1A CF FC 1D BD 19 07 2E F7 0D 77 43 AD 09 B0 89 .....wC....
    
```

  
XORing

Pseudo-Random code

```

DeRandomcode_255.dat
0: 3E 48 0E C0 9A 0D 70 BC 8E 2C 93 AD A7 B7 46 CE H...p.....F.
16: 5A 97 7D CC 32 A2 BF 3E 0A 10 F1 88 94 CD EA B1 Z..}.2..>.....
32: FE 90 1D 81 34 1A E1 79 1C 59 27 5B 4F 6E 8D 9C ...4..y.Y'[0n...
48: B5 2E FB 98 65 45 7E 7C 14 21 E3 11 29 9B D5 63 ....eE~|.!.).c
64: FD 20 3B 02 68 35 C2 F2 38 B2 4E B6 9E DD 1B 39 . ;h5..8.N...9
80: 6A 5D F7 30 CA 8A FC F8 28 43 C6 22 53 37 AA C7 j].0....(C."S7..
96: FA 40 76 04 D0 6B 85 E4 71 64 9D 6D 3D BA 36 72 .@v..k..gd.m=.6r
112: D4 BB EE 61 95 15 F9 F0 50 87 8C 44 A6 6F 55 8F ...a....P..D.oU.
128: F4 80 EC 09 A0 D7 0B C8 E2 C9 3A DA 7B 74 6C E5 .....{tl.
144: A9 77 DC C3 2A 2B F3 E0 A1 0F 18 89 4C DE AB 1F .w..*+...L...
160: E9 01 D8 13 41 AE 17 91 C5 92 75 B4 F6 E8 D9 CB ...A...u.....
176: 52 EF B9 86 54 57 E7 C1 42 1E 31 12 99 BD 56 3F R...TW...B.1...V?
192: D2 03 B0 26 83 5C 2F 23 8B 24 EB 69 ED D1 B3 96 ...&..#$.1....
208: A5 DF 73 0C A8 AF CF 82 84 3C 62 25 33 7A AC 7F ..s.....<b%3z..
224: A4 07 60 4D 06 B8 5E 47 16 49 D6 D3 DB A3 67 2D ..'M.^G.I...g-
240: 4B BE E6 19 51 5F 9F 05 08 78 C4 4A 66 F5 58 K...Q...x.Jf.X
    
```



After DeRandomizing

```

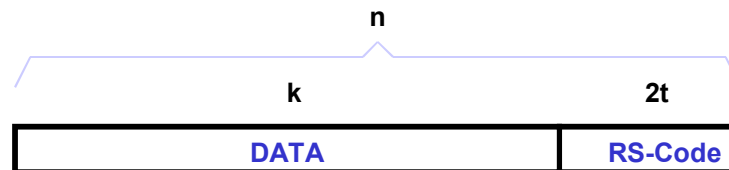
KSAT_20040209_22108_DeRandom.dat
0: 1A CF FC 1D 42 7F 00 00 00 00 00 00 00 00 00 00 .....B.....
16: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
32: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
48: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
64: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
80: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
96: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
112: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
128: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
144: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
160: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
176: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
192: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
208: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
224: D3 40 DC DD F3 B4 1B 55 6E 4B B7 57 DA 56 D4 E5 .@.....UnK.W.V..
240: DE C0 A6 D6 21 ED 05 CA 78 06 A8 04 A0 B7 72 F4 ...l...x.....r.
256: 1A CF FC 1D 42 51 09 EE 6C 00 07 FF 23 26 23 26 ...BQ..l...#&#&
272: 23 2A 34 3A 2F 2F 2A 2B 27 29 27 2C 29 25 21 23 ##4:/+)'.)%1#
288: 21 24 23 25 25 2B 26 25 22 25 1E 20 1E 20 1F 1F !$%%+&% "% . . .
304: 1D 1E 1D 1E 1C 1F 1C 1D 1A 1E 1D 1C 1B 1E 1B 1D .....
320: 1B 1D 1B 1C 1A 1B 1A 1B 1A 1B 1A 1E 1C 1E 1B 1D .....
336: 1B 1D 1B 1E 1B 1D 1B 1C 1A 1D 1A 1D 1C 1D 1B 1D .....
352: 19 1A 1B 19 17 19 1B 1A 17 1D 1C 1E 1B 1B 19 1B .....
368: 1A 1C 19 1D 1B 1F 1D 1E 1B 1E 19 1B 19 1C 1B 1D .....
384: 1B 1C 1A 1B 19 1D 1C 21 23 26 26 29 24 2A 29 2D .....
400: 28 29 28 2C 25 27 23 26 25 2C 26 26 24 27 25 27 (.)%'+&,% '%
416: 23 25 24 26 21 25 21 24 21 23 20 20 1D 23 21 24 #&$!%1$!# .#1$
432: 23 25 23 22 1E 20 1C 1E 1A 1D 1B 1F 1D 1E 20 27 #&#'.
448: 26 28 22 25 24 24 1F 20 1E 1F 1E 22 20 22 20 27 &('%%$. ....
464: 2A 30 2F 34 32 2F 2A 2B 27 29 24 28 26 26 22 26 *0/42/*+)$(&&&
480: 2B 1D 96 3D 8C 2E E9 38 82 61 DB 19 5E 53 22 85 +...8.a...S".
496: E4 D0 2C 35 FF BB 96 B7 7A 87 5E 98 F6 AC 19 7A ...5...z...z
512: 1A CF FC 1D 42 51 09 EE 6D 00 07 FF 23 25 23 24 ...BQ..m...#&$
    
```

# Reed Solomon Coding

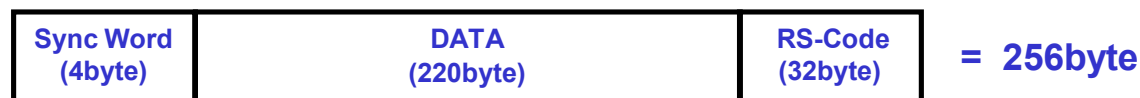
## ➤ Reed-Solomon Coding이란?

- ✓ 리드(Reed)와 솔로몬(Solomon)이 제안한 것으로 군집형태의 오류(Burst Error)에 대해 검출 및 정정할 수 있는 방법
- ✓ Reed-Solomon code is specified as  $RS(n, k)$  with  $s$ -bit symbols
- ✓ CCSDS format 에서 사용되는 RS-coding 방법 =  $RS(255, 223)$  with 8bit symbols
- ✓  $n = 255, k = 223, s = 8, 2t = 32, t = 16$

➔ input = 223 byte , output = 255 byte, rs-code = 32byte, error correction = maximum 16bytes



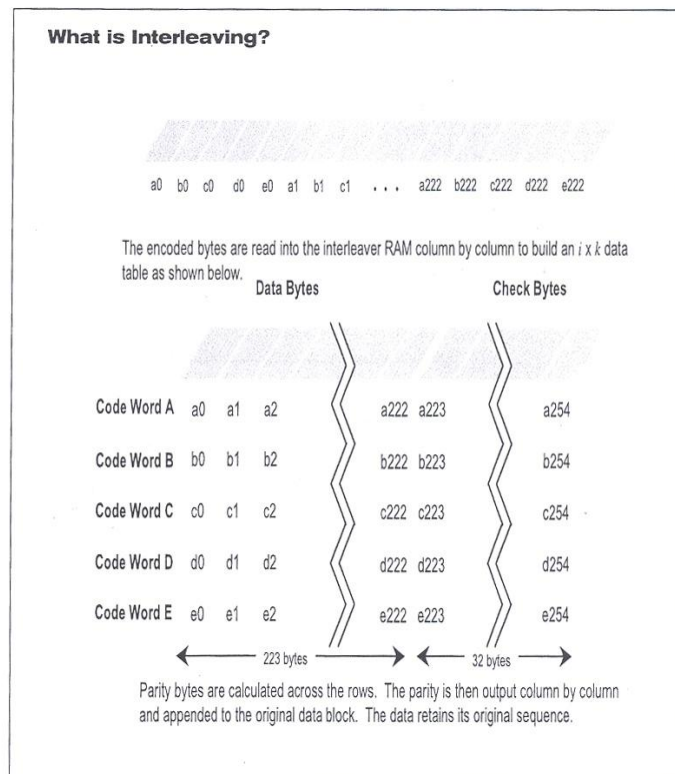
- ✓  $RS(255, 223)$  을 사용하여 인코딩을 수행하면 KOMSAT-1의 경우 sync(4byte) + data (223byte) + rs\_code(32byte) = 259 byte 가 되어야 하나 32bit 프로세싱을 위해 3byte의 virtual fill 을 사용하여 RS\_encoding을 수행한다.



# Reed Solomon Coding

## ➤ What is Interleaving ?

- ✓ 인터리빙은 데이터에서 발생할 수 있는 비트들의 연접오류를 독립오류(isolated error)로 바꾸어 줌으로써 에러정정부호의 효율을 높이고 결과적으로 **Invalid frame**의 개수를 줄여주는 역할을 한다.



## ➤ CADU size ?

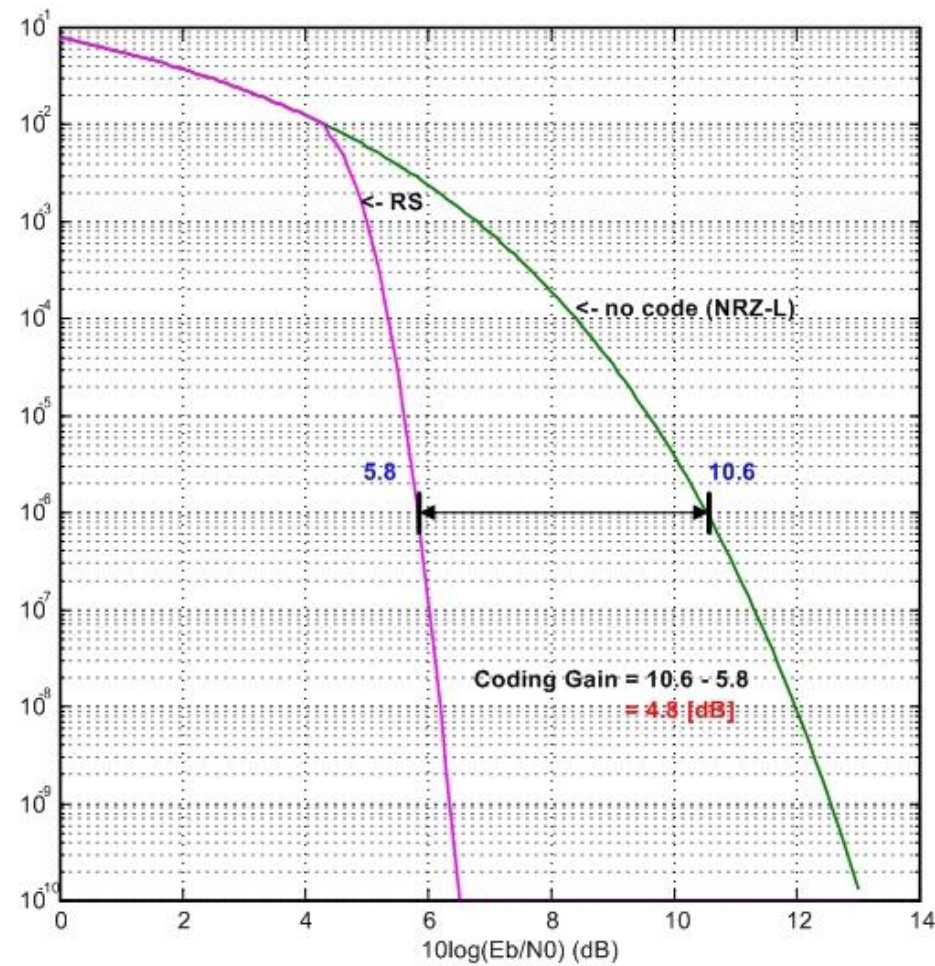
- ✓ CADU 의 size는 interleaving depth와 virtual fill 의 크기에 의해 결정된다. ( i = interleaving depth )

Sync Word (4)	DATA (223 * i)	RS-Code (32 * i)
------------------	-------------------	---------------------

- ✓ **Interleaving depth = 1**  
- data size =  $4 + (223*1) + (32*1) = 259$ . if virtual fill 3 = 256
- ✓ **Interleaving depth = 2**  
- data size =  $4 + (223*2) + (32*2) = 514$ . if virtual fill 1 = 512
- ✓ **Interleaving depth = 3**  
- data size =  $4 + (223*3) + (32*3) = 769$ . if virtual fill 3 = 760
- ✓ **Interleaving depth = 4**  
- data size =  $4 + (223*4) + (32*4) = 1024$ .
- ✓ **Interleaving depth = 5**  
- data size =  $4 + (223*5) + (32*5) = 1279$ . if virtual fill 3 = 1264

# R-S Coding Gain

Probability of Bit Error versus  $E_b/N_0$



감사합니다