

Development of KRMS and application of pilot project

2013. 8

Central Research Institute
Korea Hydro & Nuclear Power

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1. Project background
2. Project goal
3. KRMS overview
4. KRMS ADR
5. KRMS lab test
6. KRMS performance test
7. KRMS improvement
8. Discussion and comments

1. Project background (1/5)

■ Radiation safety management

- KHNP dose reduction plan : 0.50 man/Sv ('09) → 0.43 man/Sv ('14)

■ WRMS application

○ Wolsong #1 ('09. 7) : pressure tube replacement

- MGP WRMS : transmitter 48, repeater 6, transceiver 1, OS, CCTV

- Current ADR/CCTV, transmitter(ADR mount)

○ Hanul #2('11.10), #1('12.3) : S/G replacement

- MGP : transmitter 150, repeater 26, transceiver 6, OS, CCTV



50g, LiMnO₂



2.4 GHz, 10mW, 170g
65(w) x 43(d) x 120(h), AA



2.4GHz, 310g, 9V DC/VAC
70(w) x 140(d) x 30(h)



2.4GHz, 310g, VDC/VAC
140(w) x 235(d) x 40(h)

1. Project background (2/5)

■ WRMS application (continued)

- USA : Comanch peak, Arkansas nuclear one, Harris, EPRI RMT program etc.
- UK : EdF (5 years project - 58 NPPs application) etc.
 - ※ Full scale test ('10) : Gravelines, 50 mW, 3.6m distance
- Canada : Darlington (refueling, EMI test) etc.
- Japan : JAPC ('08 , self-developed EPD, 429 MHz) etc.



1. Project background (3/5)

■ Regulations

○ Korean domestic regulation

- KINS PWR safety evaluation guide ('09.12)
 - Electromagnetic interference prohibition
- Korea Communications Commission
 - Radio waves act : EMI test

※ Wireless frequency range to NPPs

Frequency	Power
2,400 ~ 2,483.5 MHz	10 mW below
5,725 ~ 5,825 MHz	

1. Project background (4/5)

■ Regulations (continued)

○ USA

- US NRC Reg. Guide 1.180 (Rev.1, 2003)
 - I&C, EMI /RFI evaluation guide : design, installation, test etc.
 - ※ MIL-STD-461 / IEC
- EPRI TR-102323 (Rev.3, 2004)
 - EMI/RFI source & susceptibility, equipment test standard etc.

1. Project background (5/5)

■ Wireless communication system applicable to NPP

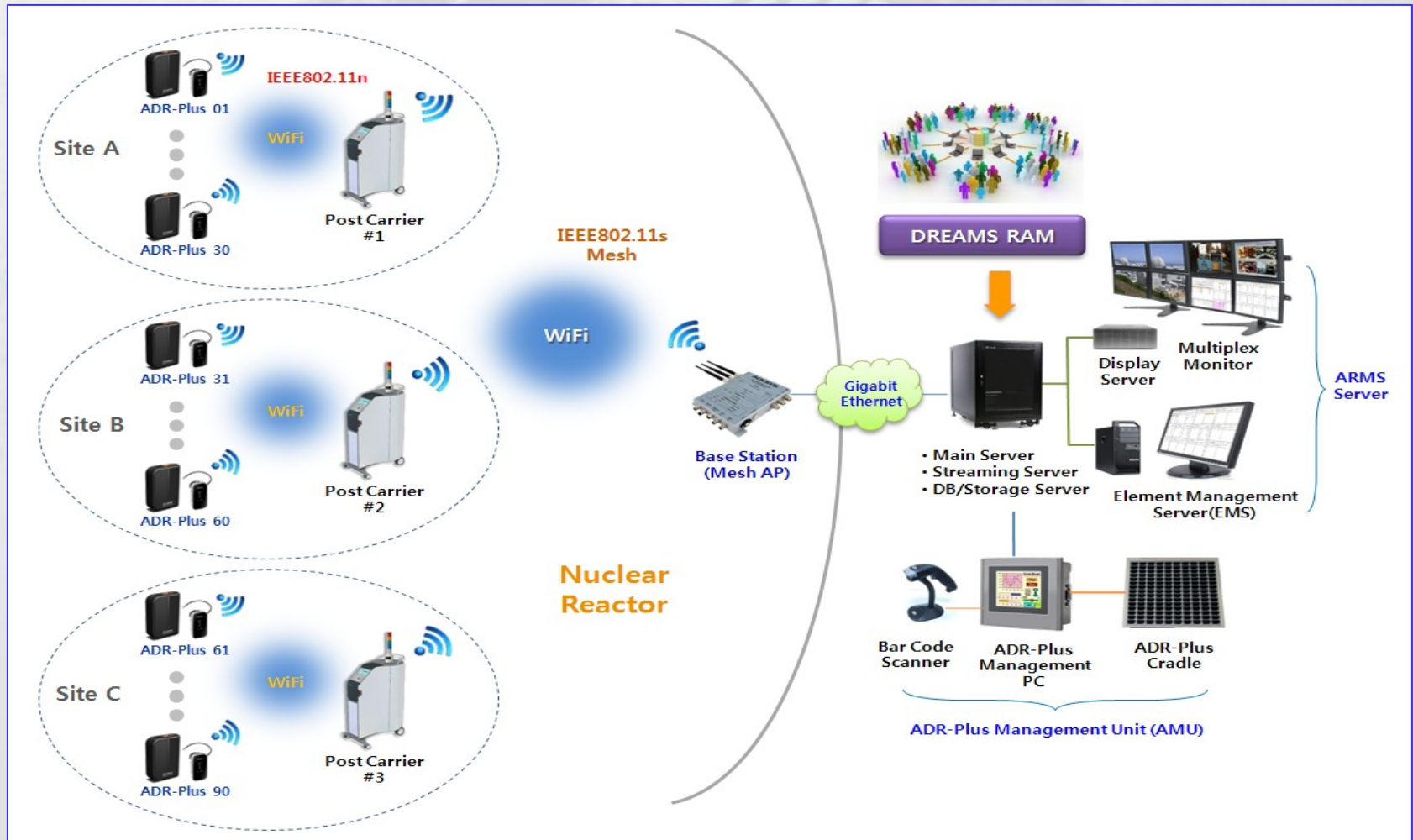
	TRS ¹⁾	WPABX ²⁾	WLAN
Base station radius (km)	30	0.05 ~ 0.2	0.3
Frequency	300 MHz 800 MHz	910 MHz	2.4 GHz
Power	1 ~ 20 W	5 ~ 10 mW	1 ~ 100 mW
Min. separation distance (m)	6.12	0.13	0.43
Connectivity with other system	Exclusive switchboard	Exclusive switchboard	PABX, Paging Phone, PC, Server, PDA, VoIP, Web Camera etc
Possibility and suitability	Low	Low	High

1) Trunked Radio System, 2) Wireless Private Automatic Branch Exchange

- Radiation Work Environment change
 - Short outage period
 - Short term labor force input growth
 - Facilities deterioration
 - Material reliability program
 - Pressure on dose reduction
- Need to develop real-time radiation monitoring system
 - Foreign system use limitation, maintenance and repair cost expensive
 - Cost benefit, expectation of export
- KHNP Real-time Remote Radiation Monitoring System Development
 - All in one communication ADR
 - Operating system

3. KRMS overview (1/2)

■ KRMS conceptual scheme



3. KRMS overview (2/2)

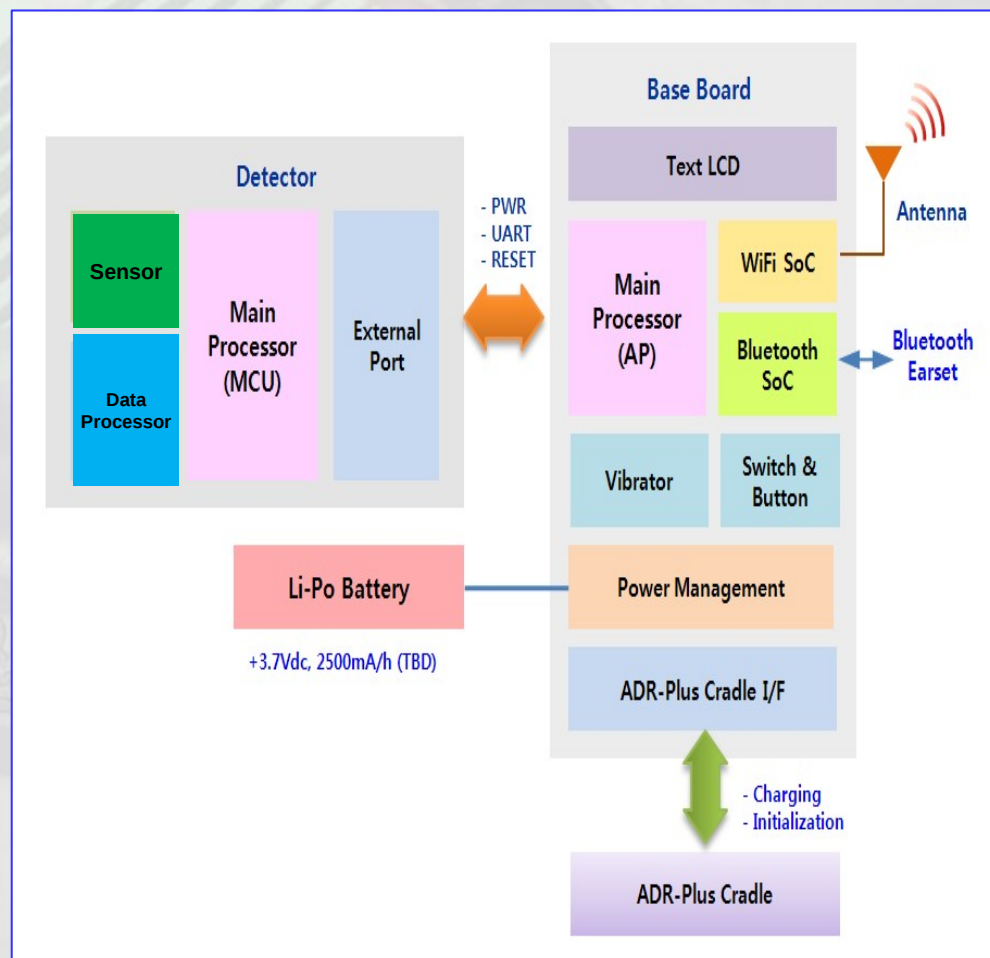
▣ KRMS main components

			
• ADR Dose / Transmission	• Repeater Transmission to Receiver	• Receiver Transmission to Server	• Integral Control System Real-time dose/work monitoring
			
• Bluetooth ear set Communication with HP	• Wireless CCTV Monitor field	• Charger rack ADR storage / charge	• Server Storage of dose / video / communication files

4. KRMS ADR (1/6)

■ KRMS ADR specifications

Item	Contents
Measuring range	○ Dose : 1 μSv to 1 Sv ○ DR : 1 μSv/h~1 Sv/h
Linearity	○ Dose : $\pm 15\%$ ○ DR : $\pm 30\%$
Energy range	60 keV to 1.2 MeV
Precision	^{137}Cs : $\pm 10\%$ uncertainty



4. KRMS ADR (2/6)

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▣ KRMS ADR



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■ KRMS ADR performance test by accreditation agency

Radiation characteristic test

- Agency : KRISS ¹⁾
 - Standard : KS C IEC 61526
 - Item : 7 (Energy dependence etc.)
 - Results : Satisfied
- 1) Korea Research Institute of Standards and Science

Electromagnetic compatibility test

- Agency : Korea EMC Lab
- Standard : Notification No. 2012-12
"Wireless radio equipment regulation" of
Korea Communications Commission
- Item : 4 (EMC etc)
- Results : Satisfied

KRISS Korea Research Institute of Standards and Science

시험결과서, Report No.: 13031-05020-KRIS From 1/3 Page

시험 성적서
TEST REPORT

시험대상, Applicant: (주)한수원발전기술연구소
주소, Address: 경기도 고양시 일산동구 일산 13-13
시험대상, Test Item: ADR-15.15
제작회사명, Manufacturer & Model: 삼성전기 (주) (SAMSUNG ELECTRONIC CO.)
모델명, Model No.: S-4000
발주일자, Date of Receipt: 2012.05.24 시험일자, Date of Test: 2012.05.30

시험내용, Description of Test
시험명, Test Name: 방사능 시험
시험기준, Test Standard: KS C IEC 61526
시험환경, Environmental Condition: 온도, Temperature: (25 ± 3) °C
시험방법, Test Method: 방사능 시험

시험결과, Test Result: 합격 (Pass)

발주자, Issued by: 서정호
발주자 연락처, Issued by Contact: 02-550-1234
발주자 이메일, Issued by Email: jhseo@kriiss.ac.kr

시험일자, Test Date: 2012.05.30

시험장소, Test Location: KRISS 방사능 시험실

시험결과, Test Result: 합격 (Pass)

시험장소, Test Location: KRISS 방사능 시험실

mke 지식경제부

수신기 한국수력원자력(주) 사장
(경유)
제작: 산하기관 보안성검열과 발원(한국수력원자력)

1. 기기의 무공해 성능을 시험합니다.

2. 국가정보통신위원회 제2012-12-12(보안성검열)에 따른 보안성검열 결과에 따라
합격 판정을 받기 위해 시험합니다.

구분	검열항목	검열결과
인수검열항목	고대역폭 주파수 선택성 검열항목	합격
인수검열항목	무선발신소 제어장치 동작 검열항목	합격
인수검열항목	선신기 원격 방사선 라디오미터 사용	합격

3. 아울러 상기 검열항목 주시시 국가정보통신위원회, 국가사이버안전관리
및 관련법령 준수사항이 반영되어, 자체 수립한 보안성검열 결과에 따라 합격 판정을 받습니다.

붙임: 검열항목 보안성검열 결과보고서 1부(별첨부), 공.

지식경제부장관

2012.05.30

KEL Korea EMC Lab

시험결과서, Report No.: 1008-01-45207

적합인증(무선분야) 시험결과서

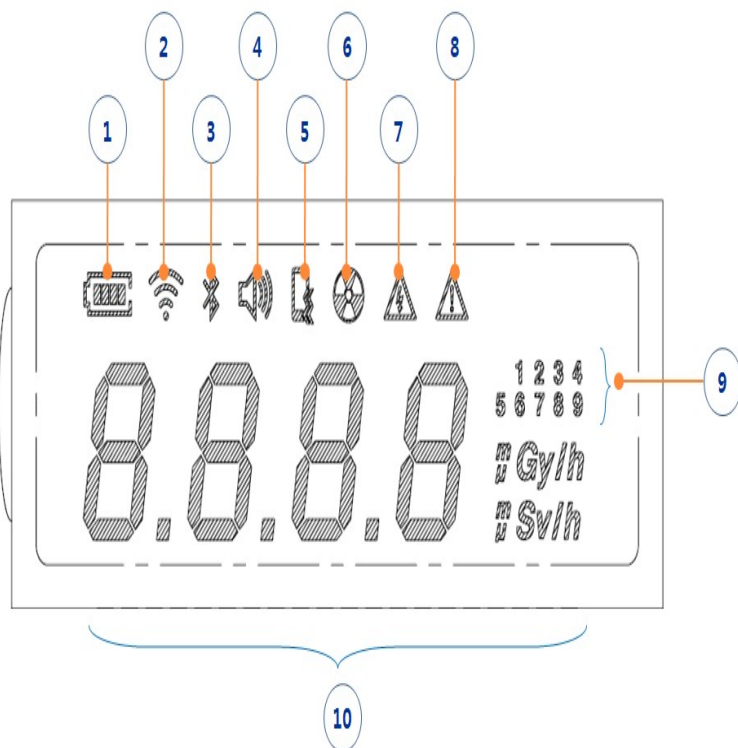
1. 발 기 호: KEL12-0051155
2. 시 행 기 간: 2012년 06월 31일 ~ 2012년 06월 08일
3. 실험항목: 무선(무선) 적합성 시험(무선) 시험항목: 무선(무선) 적합성 시험
시험대상: 무선(무선) 적합성 시험(무선) 시험항목: 무선(무선) 적합성 시험
시험결과: 합격

4. 기기명: 무선 / 무선(무선) 적합성 시험(무선) 시험항목: 무선(무선) 적합성 시험
5. 제조사명 / 제품명: 무선(무선) 적합성 시험(무선) 시험항목: 무선(무선) 적합성 시험
6. 시험장소: 무선(무선) 적합성 시험(무선) 시험항목: 무선(무선) 적합성 시험

발주자: 한국수력원자력(주) 대표이사 (인)

2012.06.14

■ KRMS ADR display



① Battery	Battery status indicator
② Wi-Fi antenna	Wi-Fi reception sensitivity indicator Icon off when wireless network doesn't need
③ Bluetooth	On when it is paired with Bluetooth Ear set
④ Buzzer	On when warning sound is activated
⑤ Vibrator	On when vibrator is activated
⑥ Warning	Flickering when dose exceeds set points
⑦ Call	Flickering when HP call is received
⑧ Charge	On when ADR is placed in cradle for charging
⑨ 1~9	Indicator of set points
⑩ FND	Worker's dose rate

4. KRMS ADR (5/6)

■ KRMS ADR weight lightening(MGP vs. KRMS)

MGP

Item	Weight(g)	Volume(cm ³)
Wireless ADR	57.15 (25.9%)	37 (12.2%)
Transmitter	112.00 (50.8%)	250 (82.2%)
Battery	51.35 (23.3%)	17 (5.6%)
Total	220.5	304



Item		MGP	KRMS	Difference
Electronic circuit	Transmitter	102 g	82 g	49 g
	Dosimetry	29 g		
Battery	Transmitter	48 g	35 g	19 g
	Dosimetry	6 g		
Case	Transmitter	20 g	18 g	17 g
	Dosimetry	15 g		
Total		220 g	135 g	85 g

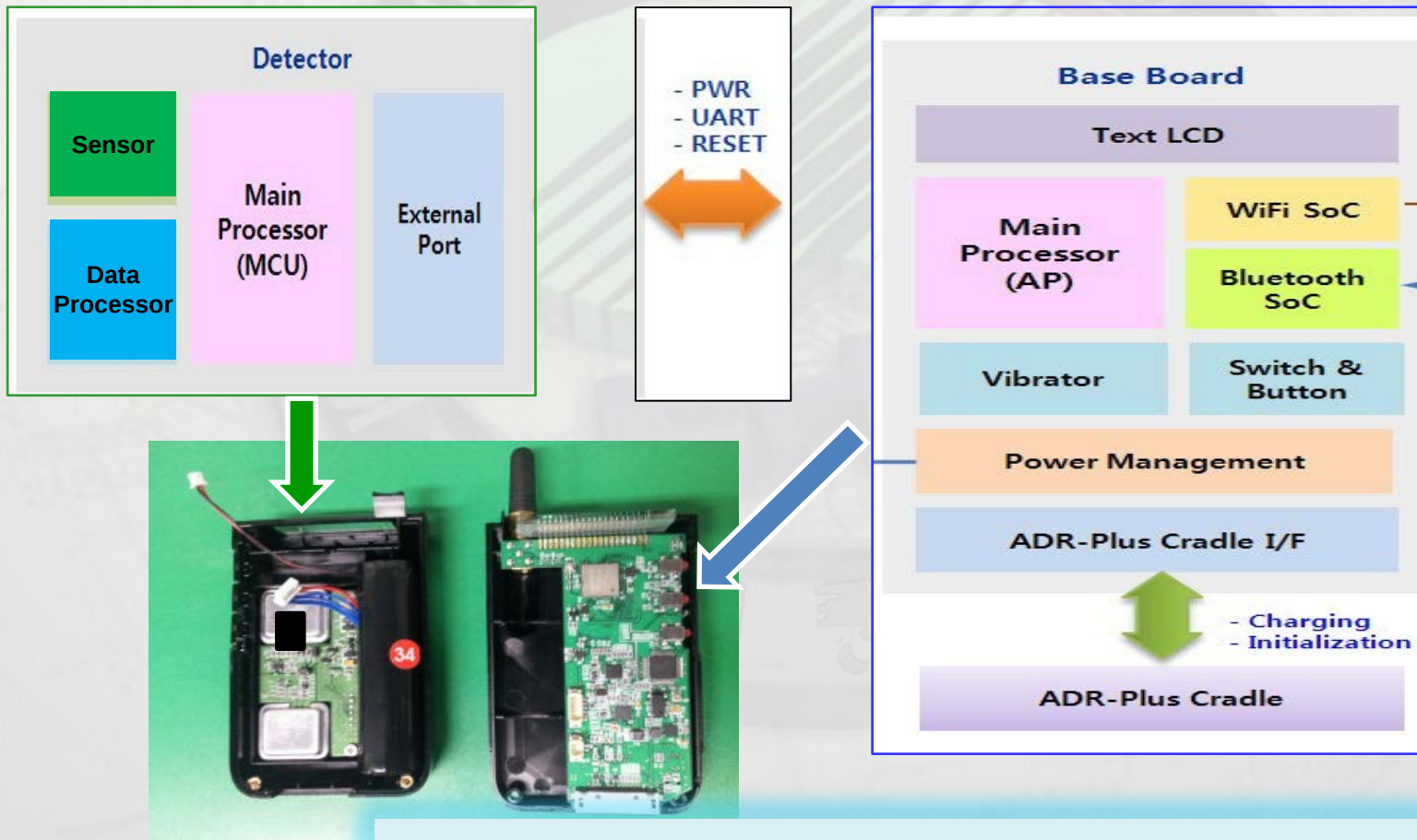
38.6%



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4. KRMS ADR (6/6)

■ KRMS all in one ADR



49g weight lightened by integral electronic circuit

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5. KRMS Lab test (1/2)

■ Lab test('12.6.11 ~15 / CRI gamma calibration room)

Classification	Item	Criterion	Results
Network	Data transmission speed	Over 50Mbps	Ok. 300Mbps
	Radio shadow area	Good / Bad	Good
ADR	Dose rate (0 ~ 50 mSv)	Within $\pm 15\%$	Ok
	Power Off	Over 7 sec.	Ok
	Battery duration	Over 8 hours	Ok
	Warning alarm	Good / Bad	Good
	Bluetooth communication	Good / Bad	Good
Integral Control System	ADR(90 EA) dose monitoring	Good / Bad	Good
	Individual worker monitoring	Good / Bad	Good
	Work Permit	Consistency/Non	Good
	Warning alarm	Good / Bad	Good
	CCTV monitoring	Good / Bad	Good
	Bluetooth communication	Good / Bad	Good
	Data storage	Good / Bad	Good
	Document Print	Good / Bad	Good

5. KRMS Lab test (2/2)

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KRMS Performance Test

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6. KRMS performance test (1/7)

■ KRMS demonstration overview : Hanbit #4 & #3

Item		Hanbit #4	Hanbit #3
Demonstration period		'12. 6. 18 ~7. 1 (14 days)	'12. 10. 17 ~ 11. 16 (31 days)
Main points		Performance test	Worker dose monitoring
Site installation	Installation period	8 days	6 days
	Integral system	Connected with portal system	Independent operation
	# of repeaters	4 EA	5 EA
Performance test	Dose monitoring spot	RCB100', 142', PZR	RCB100', 142', PZR, Rx Head
	Communication	Bluetooth	Bluetooth, wire ear set
	Video monitoring spot	5 sites(wireless)	4 sites(wire / wireless)
Real-time dose monitoring	# of target works	12 (Polar crane MR etc.)	5 (PZR Nozzle MR etc.)
	Period	2 days	9 days
	# of persons	52(CV workers at planned time)	28(CV workers at planned time)
ADR issuing time		Max 3 min/person	Within 10 sec/person

※ KRMS ADR 90, repeater 5, receiver 1, cctv 13, charger cradle 1, server, pc

6. KRMS performance test (2/7)

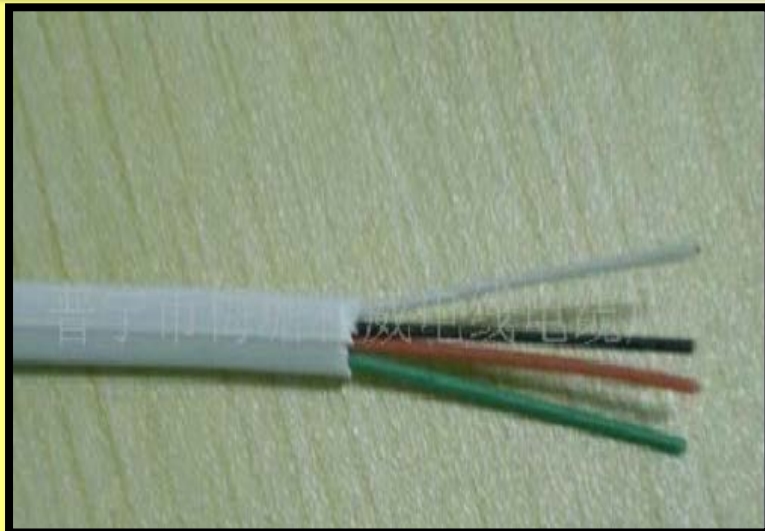
■ KRMS receive sensitivity

- Test results : normal distribution, avg -95dbm (P-value 0.559, st. dev. 15.9)
- Need to upgrade at least “- 60 dbm” for communication and video
- Communication quality improvement option
 - a) optical fiber cable pulling
 - b) local area network installation
 - c) repeater power increase
 - d) repeater installation re-location

6. KRMS performance test (3/7)

■ Optical fiber cable pulling

Before (copper wire)



After (OFC)

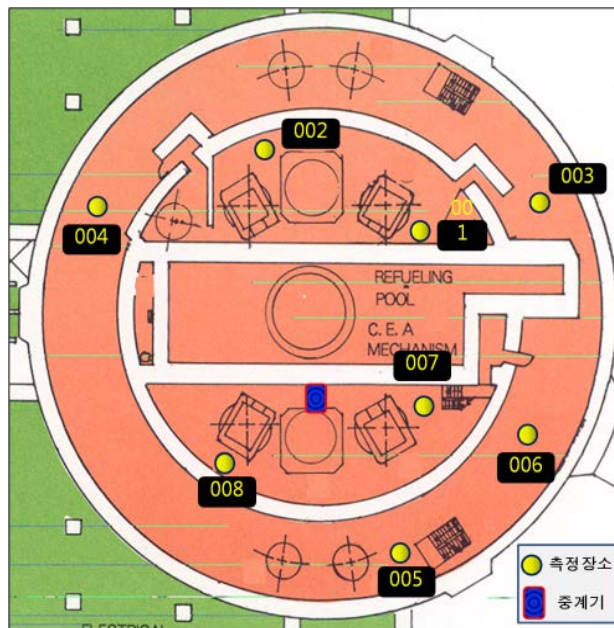


Communication Speed
~ 1000 times improved

6. KRMS performance test (4/7)

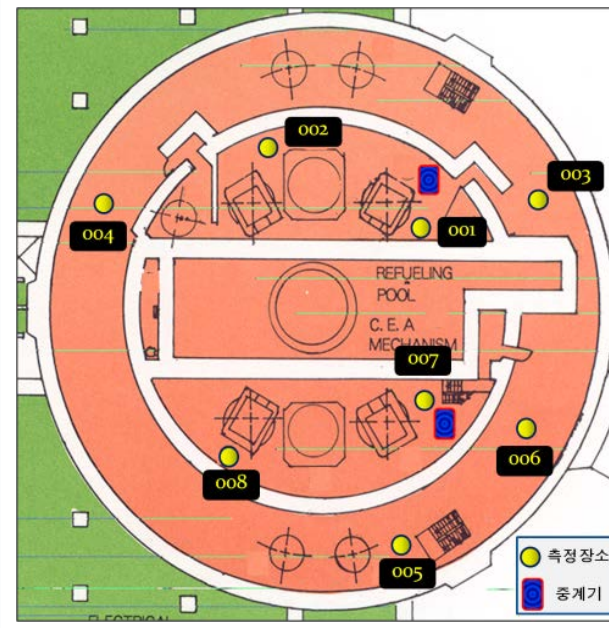
■ Repeater re-location (at RCB 100 ft)

Before



Point	Distance(m)
001	12.7
002	17.1
003	20.8
004	19.9
005	11.2
006	14.6
007	6.2
008	6.2
Avg	13.6

After



Point	Distance(m)
001	1.7
002	11.1
003	6.5
004	23.2
005	7.3
006	4.2
007	1.6
008	14.7
Avg	8.8

※ Repeaters are relocated at RCB 142 ft, 167 ft

6. KRMS performance test (5/7)

Communication quality improvement

Before

RADIO A

NAME / SSID	MODE	MAC	SIGNAL QUALITY	SIGNAL LEVEL	NOISE LEVEL
ARMS-AP	Infrastructure	8C:A9:82:2D:96:0A		-35 dBm	-95 dBm
ARMS-AP	Infrastructure	00:22:F4:0C:70:35		-89 dBm	-95 dBm
ARMS-AP	Infrastructure	00:22:F4:09:A9:BC		-87 dBm	-95 dBm
ARMS-AP	Infrastructure	00:22:F4:0C:70:26		-28 dBm	-95 dBm
ARMS-AP	Infrastructure	00:02:D1:15:8C:39		-47 dBm	-95 dBm

After

RADIO A

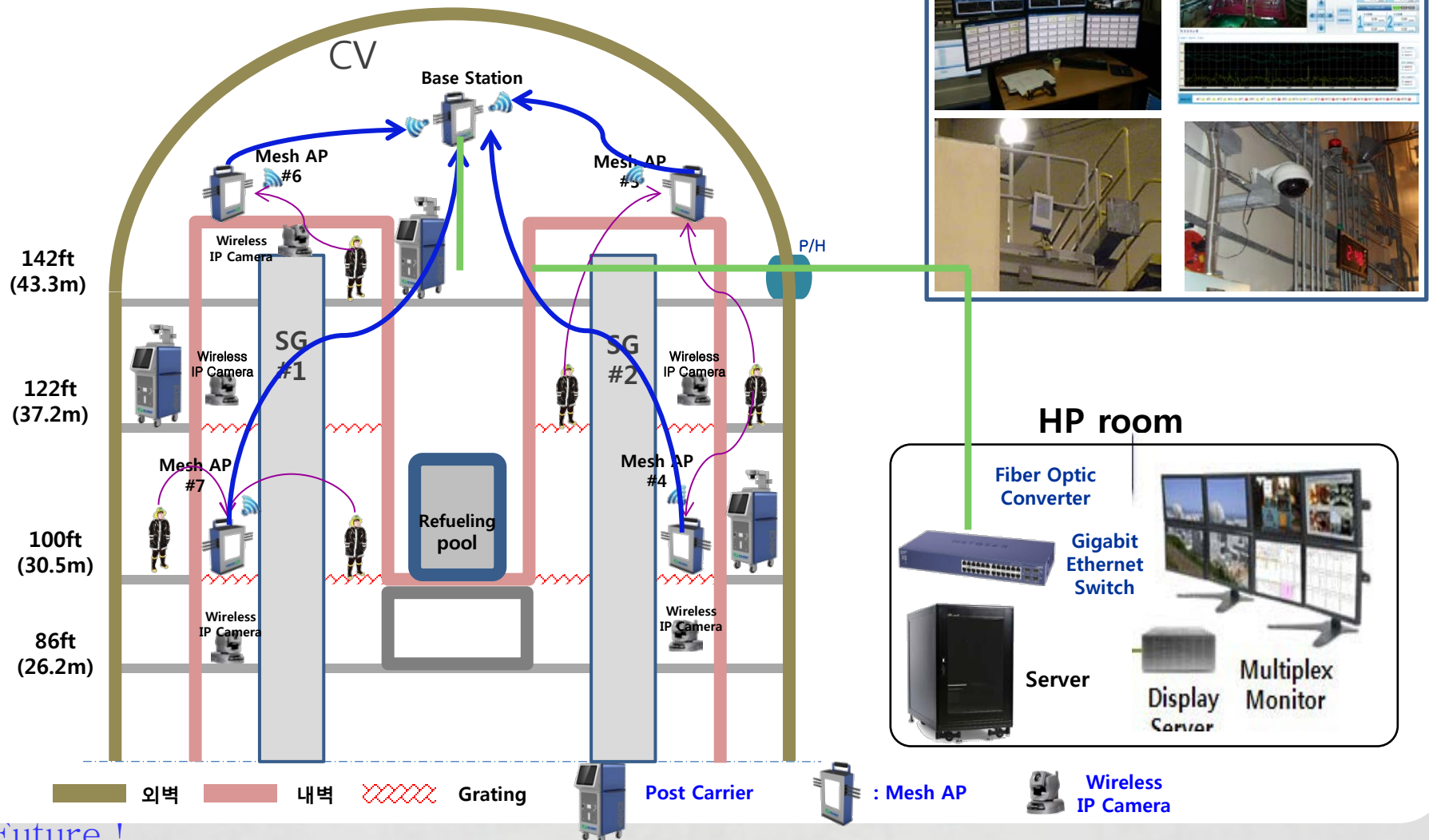
NAME / SSID	MODE	MAC	SIGNAL QUALITY	SIGNAL LEVEL	NOISE LEVEL
ARMS-AP	Infrastructure	00:22:F4:0C:71:2E		-50 dBm	-95 dBm
ARMS-AP	Infrastructure	8C:A9:82:2D:96:0A		-46 dBm	-95 dBm
ARMS-AP	Infrastructure	00:22:F4:0C:70:38		-70 dBm	-95 dBm
ARMS-AP	Infrastructure	00:22:F4:0C:70:30		-54 dBm	-95 dBm
ARMS-AP	Infrastructure	00:22:F4:0C:70:01		-54 dBm	-95 dBm

-95 dbm (σ 15.90) $\rightarrow$ -55 dbm (σ 12.48)
Avg. receive sensitivity improved

6. KRMS performance test (6/7)

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■ KRMS operating scheme



6. KRMS performance test (7/7)

■ KRMS operation



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7. KRMS improvement (1/2)

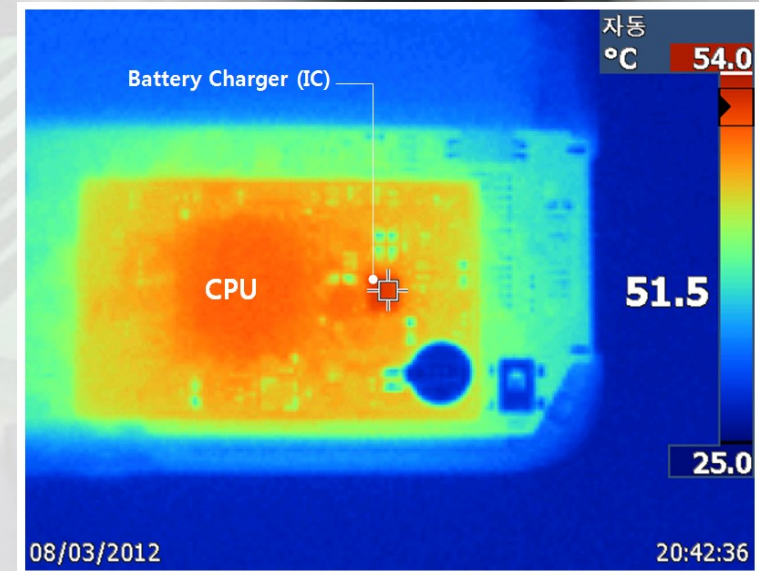
■ KRMS ADR

○ KRMS ADR heat minimized

- Battery Charger IC current adjustment
(2,000 mA → 1,363 mA)
- PCB circuit replacement
- Result : 51.5°C → 45°C

○ ADR issuing time shortened

- Setup time decrease by using wire ear set and preliminary setup
- Software upgraded
- Result : 3 min/person → 10 sec/person

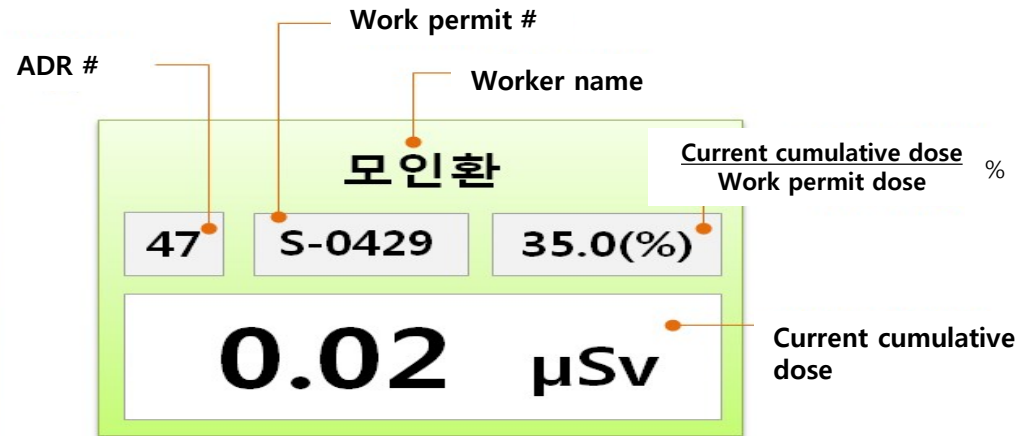


7. KRMS improvement (2/2)

■ KRMS ADR display



< Before >



< After >

○ Repeater connection status



8. Discussion and comments

- KRMS application
 - Use during outage
 - Worker dose management especially in high radiation working area
 - Emergency work in accident or prevention
- KRMS future works
 - System miniaturization and simplification
 - Installation user convenience improvement

Thank you



친환경 에너지 기업



한국수력원자력주