DEVELOPMENT OF DISASTER PREVENTION APPLICATION FOR ACCELERATOR TUNNEL USING POSITIONING SYSTEM

2019 ITSF meeting @ LUND

Yasuo Kawabata A), Hiroaki Matsuda A), Kazunobu Matsumoto A), Shigeaki Tagashira B), Koji Ishii C), Chihiro Ohmori C), Masakazu Yoshioka D)

A) TOBISHIMA Corp., B) Kansai Univ., C) KEK/J-PARC Acc., D) Tohoku Univ., Iwate Univ.

Joint Research by TOBISHIMA Corp. and KEK/J-PARC Acc.
(Fiscal Year: 2015 – 2018)

1) Motivation of this research
2) Studies
   2-1) Radiation Hardness
   2-2) Application Development
3) Future Plan
2011 EAST JAPAN EARTHQUAKE

2011.Mar.11
Earthquake disaster while working inside the MR tunnel
⇒ Evacuated from the C1 entrance

You Tube : J-PARC earthquake

~ 400 m
Future Accelerator Tunnel (ILC: ~20 km)

System Image

- Confirm evacuation situation in real time
- Visibility the rescue target

Monitoring Room

Network?

Worker’s Terminal

- Fire Occurred at P1
- Evacuate to the North, Immediately

- Real time information of the accident
- Instruction of evacuation

8/25 Evacuation Done

Need Rescuer at P2

- Network?
Technology Choice

Recent Indoor Positioning System

- Wifi
  a few m accuracy

- BLE (Bluetooth Low Energy)
  ~ 1 m accuracy

- UWB (Ultra Wide Band)
  less than 1 m accuracy

- PDR (Pedestrian Dead Reckoning)
  ~ 1 m accuracy

⇒ We choose the Wifi having communication available

In the J-PARC there is an issue of the radiation
(Even if at the ILC we need to investigate radiation hardness of the system)
Study of the radiation hardness
J-PARC MR tunnel (Insertion A in 2015)

Collimator

Quadrupole

~ 0.14 Gy/h @ Rad-Mon (FX beam operation)

PC

7.5 m

BEAM

concrete

Rad-Mon

BLE

Bluetooth Low Energy

Access Point

custom AP / commercial AP
Radiation Monitor (provided by CERN)

\[
\text{192 Gy / 59 days = 3.26 Gy/day} \\
\text{= 0.14 Gy/h}
\]
2015.October Irradiation test @ MR tunnel

<table>
<thead>
<tr>
<th>Broken Date/Time</th>
<th>Device</th>
<th>Total number of shots</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015/10/15 22:28</td>
<td>Beacon4</td>
<td>~ 0.5k shots (HD supply)</td>
</tr>
<tr>
<td>2015/10/17 0:54</td>
<td>Beacon3</td>
<td>~ 7k shots (HD supply)</td>
</tr>
<tr>
<td>2015/10/17 1:55</td>
<td>AP4 (wireless)</td>
<td>~ 8k shots (HD supply)</td>
</tr>
<tr>
<td>2015/10/17 5:33</td>
<td>AP3 (wire &amp; wireless)</td>
<td>~ 10k shots (HD supply)</td>
</tr>
<tr>
<td>2015/10/17 9:04</td>
<td>AP1 (wire &amp; wireless)</td>
<td>~ 12k shots (HD supply)</td>
</tr>
<tr>
<td>2015/10/17 19:53</td>
<td>AP2 (wire) &amp; AP4 (wire)</td>
<td>~ 12k shots (SX study)</td>
</tr>
<tr>
<td>2015/10/19 18:05</td>
<td>Beacon2</td>
<td>~ 29k shots (HD supply)</td>
</tr>
<tr>
<td>2015/10/20 0:44</td>
<td>Beacon1</td>
<td>~ 32k shots (HD supply)</td>
</tr>
</tbody>
</table>

SX study / HD user operation

- Beacon4
- Beacon3
- AP4 (wireless)
- AP3 (wire & wireless)
- AP1 (wire & wireless)
- AP2 (wire)
- Beacon2
- Beacon1

MR.CQ:TMG.CER:EVENT:P3_CNT

Less than 0.1 Gy
2016.February  γ-ray irradiation test @ ATOX

ATOX Co. Ltd. Irradiation Facility @ KASHIWA

1) 1.0 Gy/h  9:17 start  10:17 stop
2) 10 Gy/h  10:36 start 11:36 stop
3) 100 Gy/h 11:54 start  12:54 stop
4) 1000 Gy/h 13:14 start  14:14 stop

<table>
<thead>
<tr>
<th>No.</th>
<th>Status</th>
<th>MAC</th>
<th>Power</th>
<th>WiFi</th>
<th>Wired</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>ON</td>
<td>7F18</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>②</td>
<td>ON</td>
<td>0800</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>③</td>
<td>ON</td>
<td>84F0</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>④</td>
<td>OFF</td>
<td>EE70</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>⑤</td>
<td>OFF</td>
<td>9848</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>⑥</td>
<td>OFF</td>
<td>9560</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

When γ-ray irradiation is up to the total 1kGy all APs were broken.

If during the irradiation AP’s power was off, AP can work up to the excess 1kGy.
# 2016. February Irradiation test @ MR tunnel

<table>
<thead>
<tr>
<th></th>
<th>Power OFF</th>
<th></th>
<th>Far Installed by antenna extension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GF04B</td>
<td>GF156</td>
<td>WAPS-AG300H</td>
</tr>
<tr>
<td>Wired</td>
<td>Wired</td>
<td>Wired</td>
<td>Wired</td>
</tr>
<tr>
<td>WiFi</td>
<td>WiFi</td>
<td>WiFi</td>
<td>WiFi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Setup</th>
<th>2016/1/14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>2016/2/3</td>
</tr>
<tr>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Check</td>
<td>2016/3/9</td>
</tr>
<tr>
<td></td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Dose (Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ 100 Gy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FX operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016/1/22</td>
</tr>
<tr>
<td>2016/2/3</td>
</tr>
<tr>
<td>2016/2/15</td>
</tr>
<tr>
<td>2016/2/27</td>
</tr>
<tr>
<td>2016/3/10</td>
</tr>
</tbody>
</table>
Every 50 m from C1 to INS-A a total of 9 APs is installed
AC line and wired network are connected in series
During the maintenance (after the beam stopped), enter in the tunnel and power on the base device
Bring the launched PC to the tunnel and confirm the alive
⇒ After 2018 autumn, wired connection on the ground PC
Automatically OFF of device power (introduces a timer)
Irradiation test @ MR tunnel

Total DOSE (Gy)


Equivalent to 1k Gy for 2 years (Insertion A)

No failure

New 9 APs are installed

2017  ~ 450 Gy

2018  ~ 620 Gy
In the environment of total γ-ray irradiation dose is under 2k Gy or less, if power of device is OFF state, it will not be broken even with a commercial one. (ILC: less than 1 mGy/h = million hours are OK)
Development of the prevention application
(A) It can be operated in a local closed environment that is disconnected from the outside (from a security point) ⇒ In the future automatic acquisition of earthquake information etc.
(B) Function to get worker positioning by wireless LAN
(C) 2 ways communication, message recording, and marked as read function
(D) Worker status (abnormality) monitoring function
A timer of the AP device power line (Automatically OFF)
Administrator screen
Positioning monitor is a simple method to identify with the closest AP (cell-ID)
Management by administrators (at the disaster)
Worker screen (smartphone)

Position Information

Message browser

Read management

Like LINE app.
Sharing information in the tunnel (easy taking picture)
Evacuation instruction ⇒ Confirm the direction
Worker's abnormality (No response with smartphone acceleration sensor)

⇒ Move to other workers for relief / rescue
Latest Progress (2018 Dec.)

Wearable information terminal (even when working and noisy)

Useful stamps

Prepare to expand the whole MR ring
In the future
Total 33 APs will be installed.
Version 1.0.0 will be released ⇒ Use for MR workers
Caution: Magnet in operation

High Radiation Area

Tsunami warning: after 10 minutes, 3 m

Enter/Exit Management

Tunnel information (when entering)

Caution: 2 mSv/h High Radiation Area

Caution: 0.8 mSv/h High Radiation Area

2020?
Merging with radiation management (who, where, when, how much dose)

Enlargement

For the radiation work in higher environment, additional APs are installed to improve the position accuracy.

Recoding the time, the position (place), and the radiation dose
Radiation hardness is studied and found the AP for Wifi is not broken up to 1 k Gy even in the J-PARC MR environment. (Neutron and Gamma)

MR disaster prevention application with positioning system is READY. (During the beam operation AP’s power should be OFF)

In 2019 summer we want to release the first version and use it in MR. (feedback for the application improvement)

For a future prospect, if this system can be developed successfully it can be expected to be utilized in various facilities.

If you are interested please contact me; koji.ishii@kek.jp
J-PARC Facilities

A joint project of JAEA (Japan Atomic Energy Agency) and KEK (High Energy Accelerator Research Organization)

MLF (Material and Life Science Experimental Facility)

Hadron Experimental Facility

3 GeV RCS (Rapid Cycle Synchrotron) (25Hz, 1MW in design)

Neutrino Experimental Facility

400 MeV Linac

30 GeV MR (50 GeV - 0.75 MW in design)