WSN Test beds for Fast Breeder Reactor and its related Experimental Facilities

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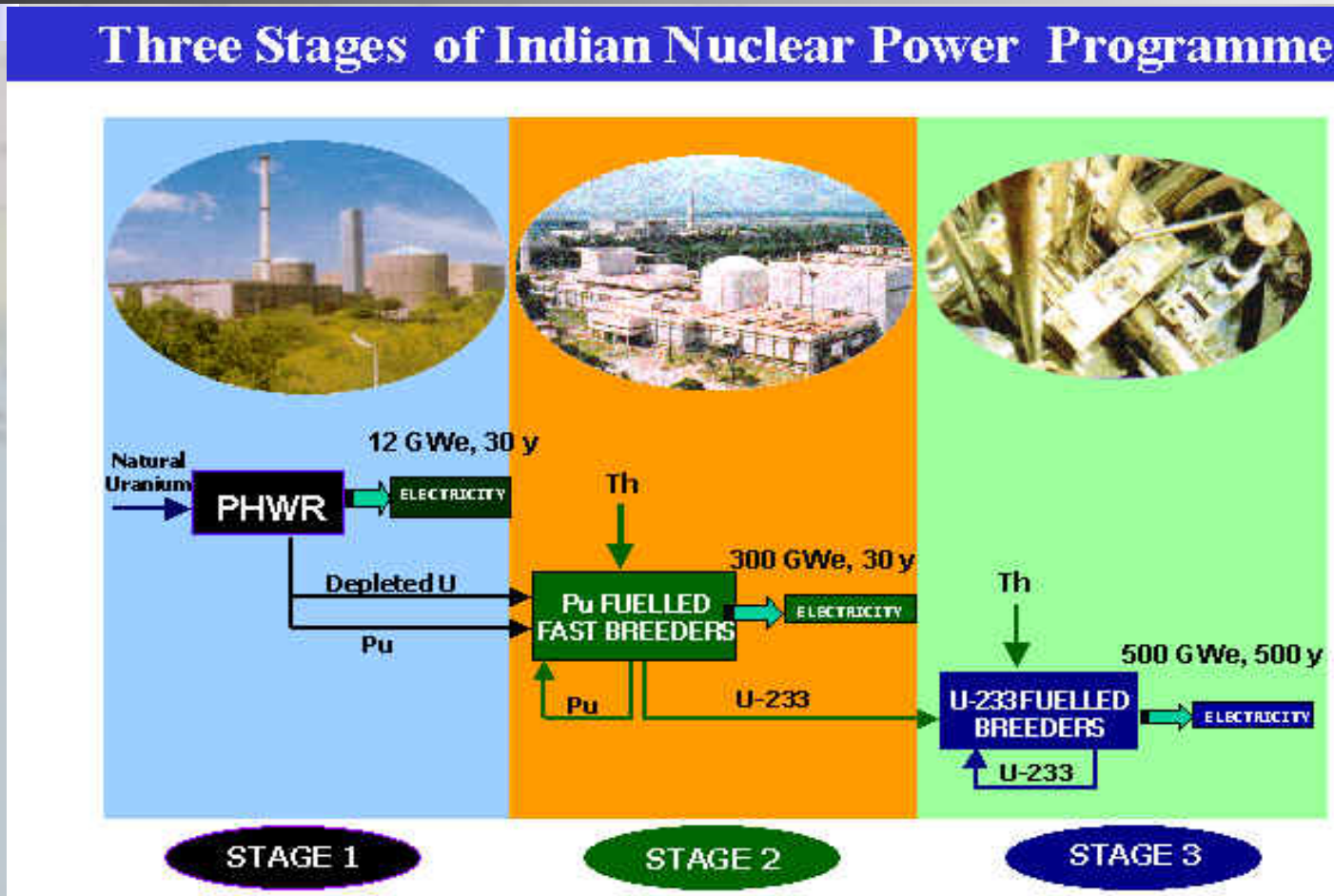
Incredible India

Indian Nuclear Power Programme



Indira Gandhi Centre for Atomic Research

- Directed towards design of Fast Breeder Reactors.

Why WSN needed for Nuclear Reactors??

- Radiation monitoring in and around reactor building
- Reducing/ Eliminate the no of penetration in RCB
- Wirelessly handling radioactive equipments, sensors, valves
- Enhancing the safety of reactor during situations, such as station blackout or any accidental situation like natural calamity ; when signals are not able to reach control room. Signals can be monitored and controlled if they are made available wireless
- Reducing the reactor down time if fuel handling is wireless (more important in the reactors where offline fuel handling is done).
- Providing redundant paths for critical signals and reducing cabling for non safety signals.
- Monitoring and indicating if any unauthorized person enters control room

WSN test beds deployed in various IGCAR facilities:

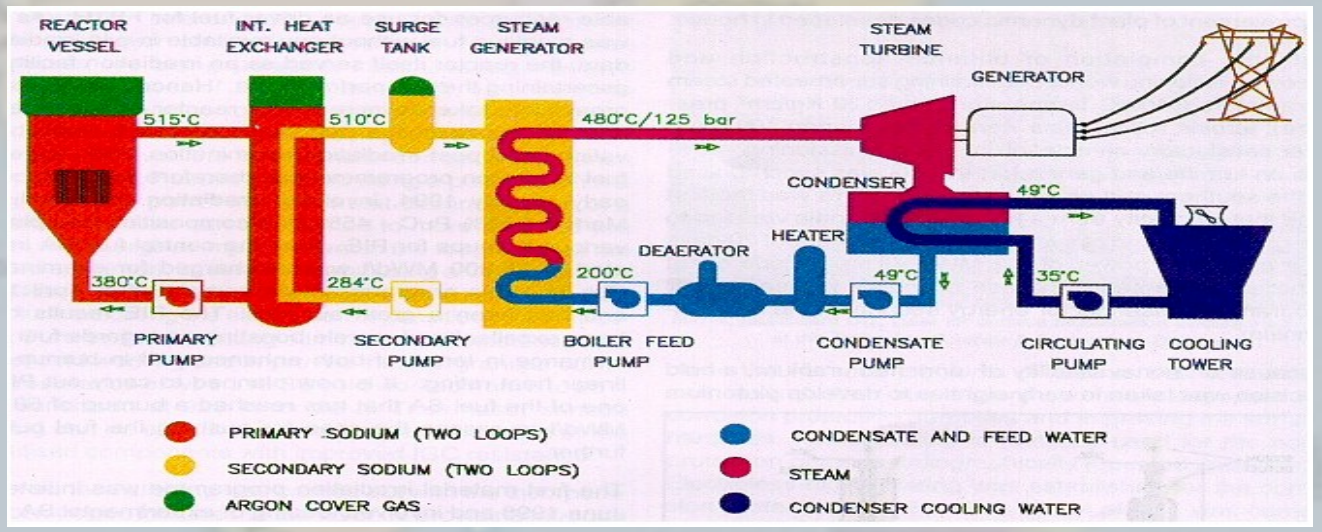
- Fast Breeder Test Reactor
- SAfety grade Decay Heat removAl loop in NAtrium (SADHANA) facility
- IN SOdium Test (INSOT) facility

…. What are these facilities and network description we will see in couple of slides

Frast Breeder Test Reactor

- **The Fast Breeder Test Reactor** is a 40 MW t, loop type, sodium cooled fast reactor. Figure shows the schematic flow sheet of the heat transport circuits

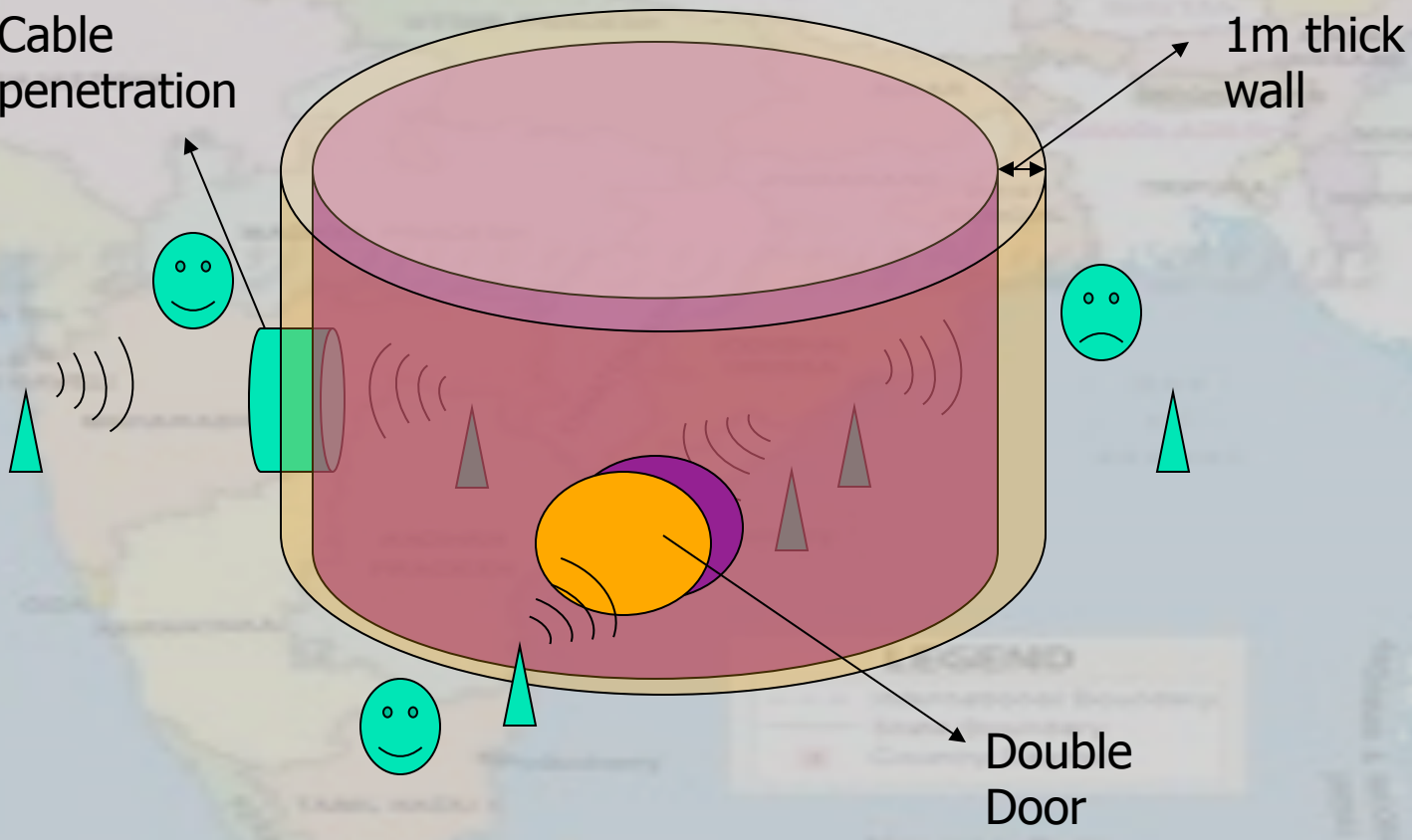
Just for Curiosity:



WSN experiments done in FBTR

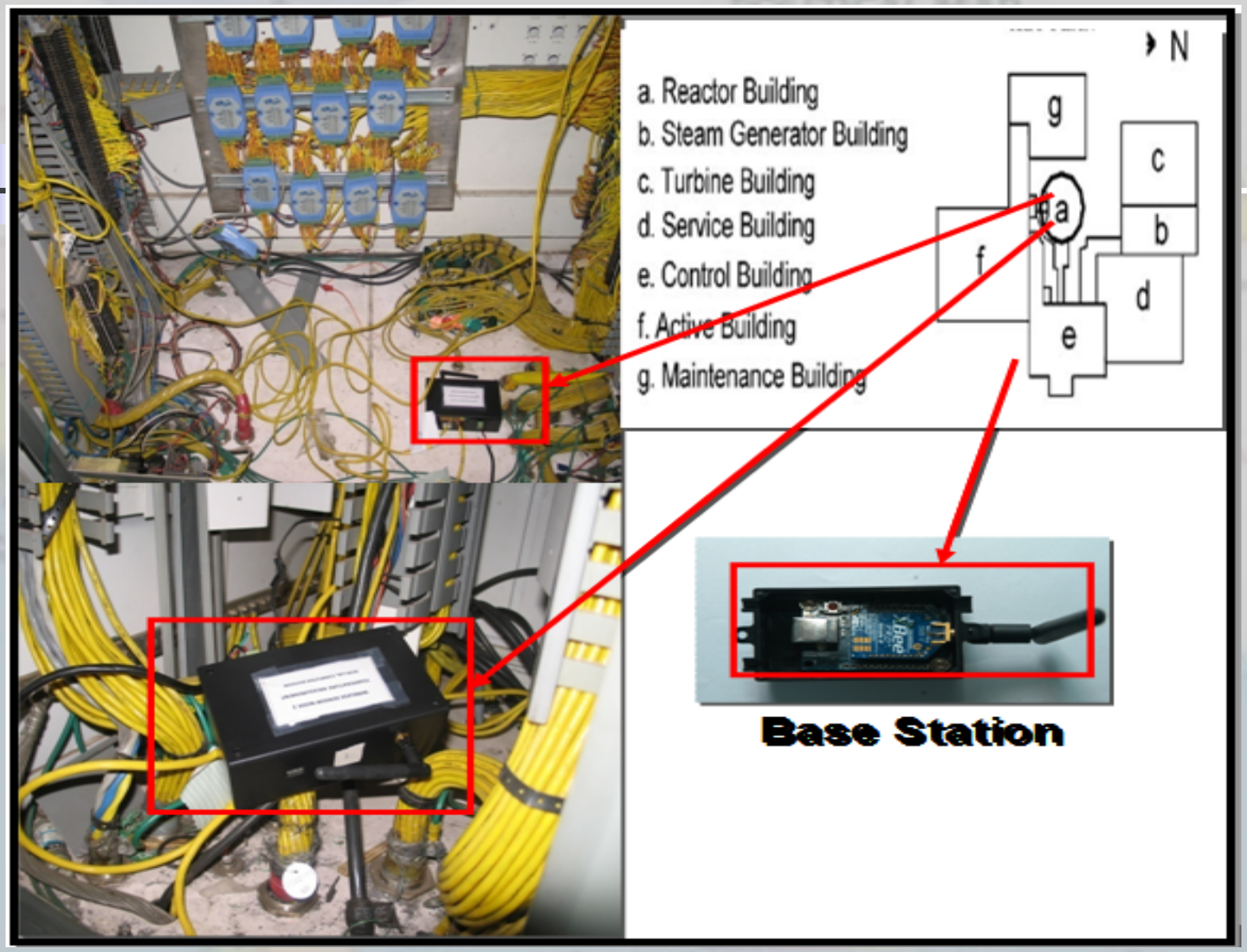
- Test: Checking the feasibility of wireless communication across 1m thick Reactor Containment Building wall has been tested using different radios (RF230, X-bee, X-bee pro, Wi-Fi Access Points) with different gain antennas (max antenna gain 7dBi).

Reactor Containment Building



WSN test bed established in FBTR

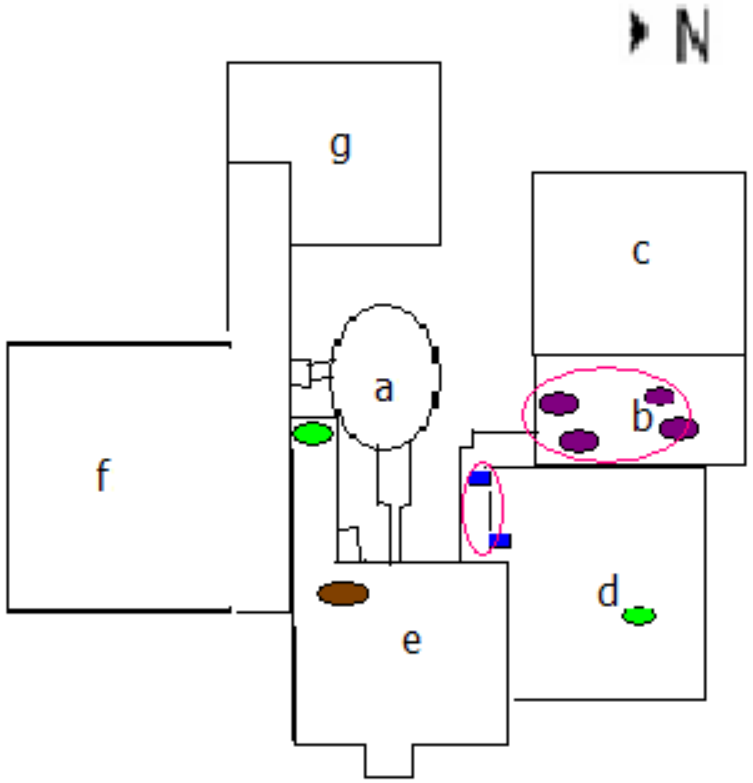
- **Test bed 1:** Four numbers of non nuclear safety signals (2 Primary Thermo Fluid temperatures, Tube side of Heat Exchanger temperature, Purification circuit bypass valve temperature) have been connected to nodes placed inside RCB (***a*** in fig.) and the data has been routed to control room (***e*** in fig.) through 3 routers.


a. Reactor Building
b. Steam Generator Building
c. Turbine Building
d. Service Building
e. Control Building
f. Active Building
g. Maintenance Building
N
g
c
a
b
f
d
e
Base Station

- **Test bed 2:** It is WSN network to collect the sensor data around the reactor building. Network consist of of 4 K-type temperature sensor nodes and 2 vibration nodes. Two routers are also used to provide redundant path to route sensor data to control room.

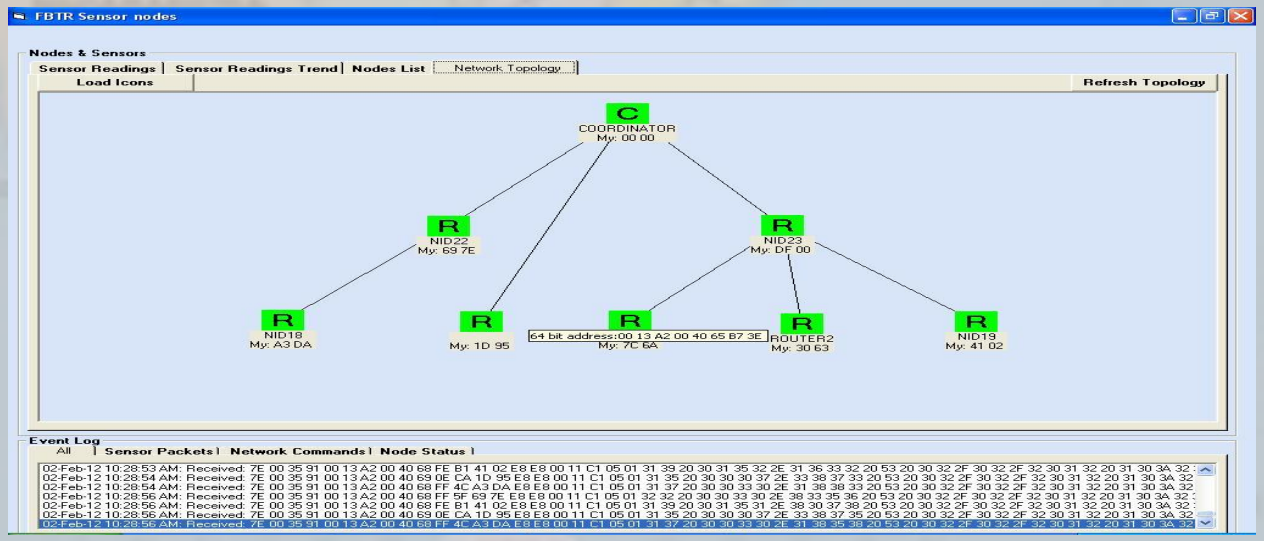
a: Reactor Building
b: Steam Generator Building
c: Turbine Building
d: Service Building
e: Control Building
f: Active Building
g: Maintenance Building

Vibration Sensor Node
Temp Sensor node
Base Station
Router
At different floor level



Status of WSN Test bed 2

- Data collected and logged every 2 sec
- In –house made network monitor tool used to monitor throughput of network, to show current topology



- Network is operating since last 3 months.
- As per observations network monitor tool is updated continuously and gives us data that which node is down.
- Plans are to increase the sensor nodes.

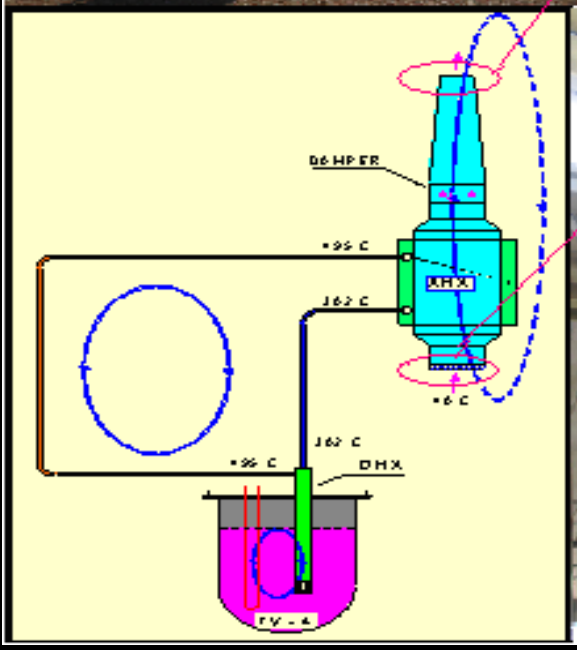
Temperature and Humidity Monitoring at SADHANA facility

- It is test facility to study the Safety Grade Decay Heat Removal of PFBR.The 20m high Chimney develops the air flow required to transfer the heat from secondary sodium to the atmosphere through the AHX.
- When the loop is in operation, it is necessary to continuously monitor the temperature and humidity at chimney outlet (11th floor) and chimney inlet (5th floor) from the control room (2nd floor). Laying cables for long distance is cumbersome task in already established plant. Hence.....

.....WSN network is established vertically

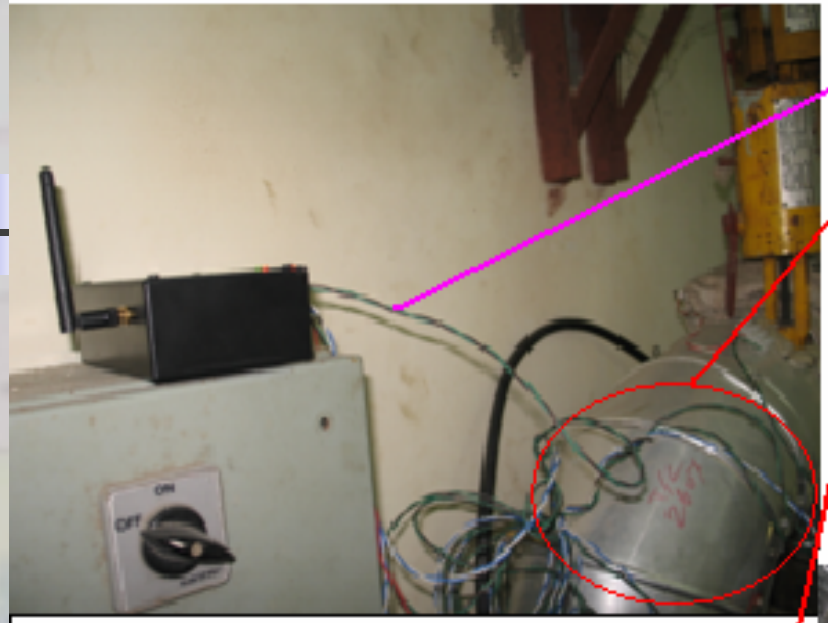
Humidity and temperature Sensor at Chimney Outlet(on Roof)

Humidity Sensor at Chimney Inlet at 5th floor



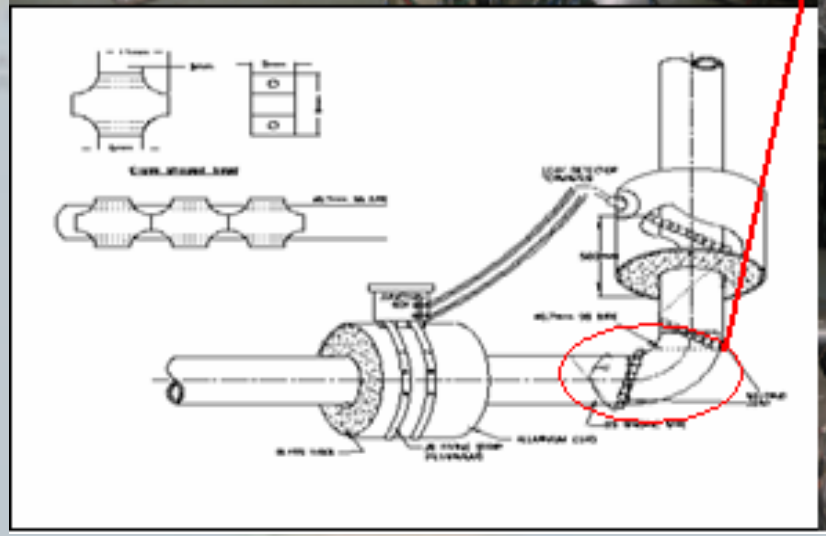
Sodium Leak Detection at INSOT facility

- At IN SOdium Test (INSOT) facility, IGCAR, two numbers of test sodium loops are established for creep and fatigue testing. Each loop has nearly 140 sodium leak detectors that are wired to control room. There is a possibility of avoiding wires for future applications. As an experimental setup, 9 numbers of leak detectors distributed across three floors have been chosen and the wireless sensor network has been established.

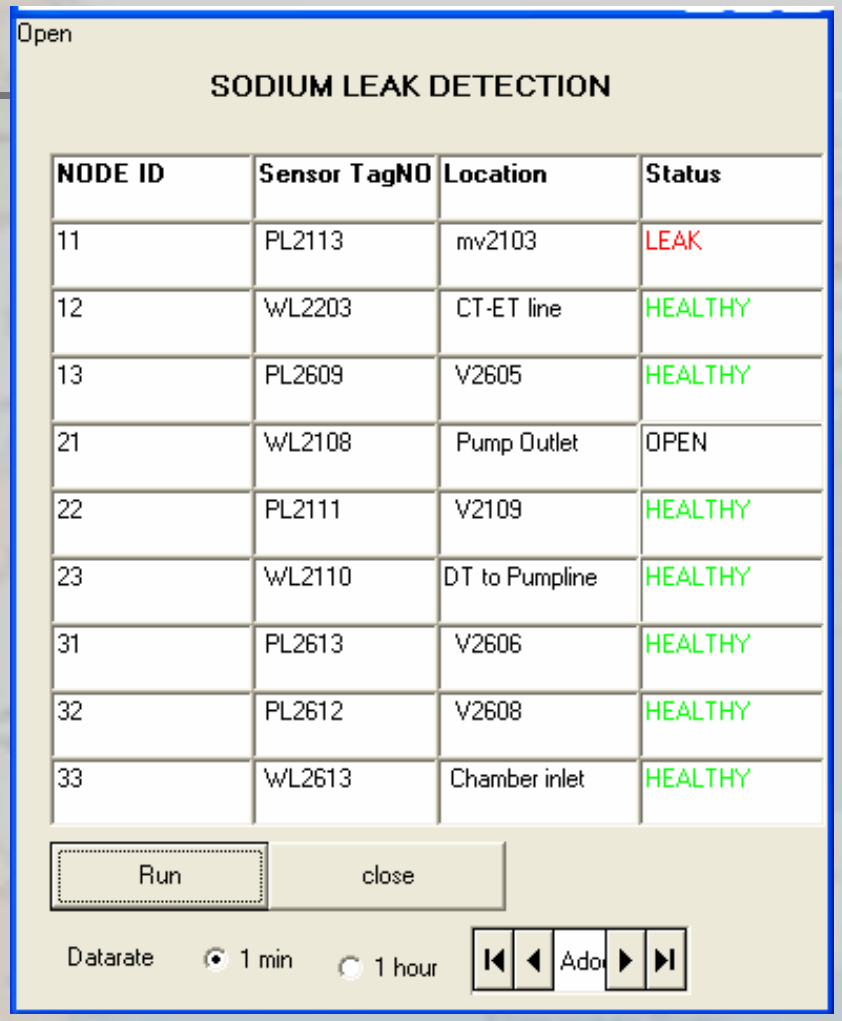


Leak Detector Cable

Sodium pipes over which Leak Detectors are wounded. All pipes are grounded. In case of Na Leak Impedance change is detected



Sensor status monitored in Control Room

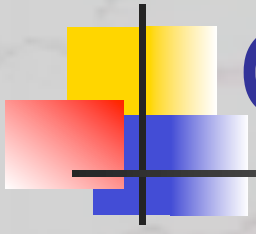


In house developed Node 1 Features

- **Microcontroller**- ARM7 based microcontroller to process all the relevant data and capable of running software stack.
- **Transceiver-** XBee (or) XBee-Pro chip, operates in the 2.4 GHz ISM band. Modulation scheme- O-QPSK and Spreading method- DSSS.
- **Power source-** Mains powered. Optionally can be powered by battery and USB.
- **Sensor interfaces-** Analog(10 bit internal ADC and 12 bit External ADCs) and digital (SPI,I2C) interfaces.
- **Programming interfaces-** ISP, USB
- **Antenna Interface-** RP-SMA Connector

In house developed Node 2 Features

- **Microcontroller**- Cortex-M3 based microcontroller to process all the relevant data and capable of running software stack.
- **Transceiver-** RF230 chip, operates in the 2.4 GHz ISM band.
- **Power source-** Mains powered. Optionally can be powered by battery and USB.
- **Sensor interfaces-** Analog(12 bit ADCs) and digital (SPI,I2C) interfaces. Integrated humidity and temperature sensor.
- **Programming interfaces-** ISP, USB & JTAG
- **Antenna Interface-** RP-SMA Connector

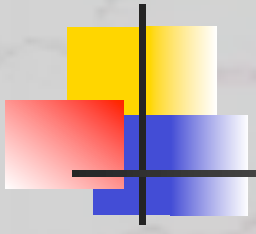


Conclusion:

Lots of things to be done, its just a beginning..

- Find an appropriate solution for RCB wall penetration
- Design a routing protocol/ hybrid channel access technique which can handle both critical , safety signals and non safety signals as per the priority of signal
- Including security protocols
- Enhancing the node design to withstand high temperature
- Radiation hardening of the nodes.

Question Time



Thank You

List of Thermal Nuclear Power Plants in India

Location	Unit Name[a]	Capacity (net MWe) [b]
Kaiga, Karnataka	Kaiga 1	202
	Kaiga 2	202
Kakrapar, Gujarat	Kakrapar 1	202
	Kakrapar 2	202
Kalpakkam, Tamil Nadu	Kalpakkam 1	155
	Kalpakkam 2	155
Kota, Rajasthan	Rajasthan 1	90
	Rajasthan 2	187
	Rajasthan 3	202
	Rajasthan 4	202
	Rajasthan 5	450
	Rajasthan 6	450
Kudankulam, Tamil Nadu	Kudankulam 1	1,000
	Kadunkulam 2	1,000
Narora, Uttar Pradesh	Narora 1	202
	Narora 2	202
Tarapur, Maharashtra	Tarapur 1	150
	Tarapur 2	150
	Tarapur 3	450
	Tarapur 4	450