



Wireless in nuclear feasibility study

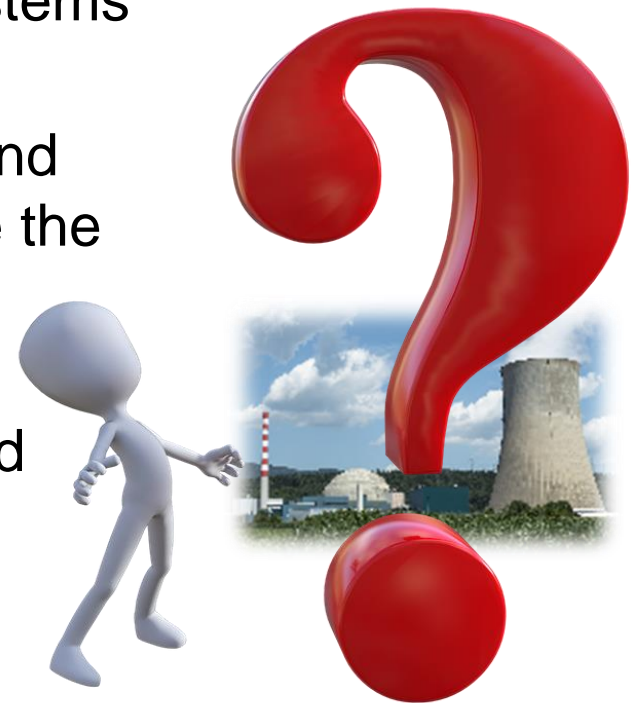
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Motivation for the study

- Wireless technologies have developed very much
- Novel sensors and radio technologies provide the opportunity to create extensive wireless sensor networks to monitor and control complex systems without wires.
- Wireless enables the mobility of personnel and applications creating new ways to rationalize the operations in all business sectors.
- Freedom from wires opens opportunities to develop systems into processes, where wired systems would not be possible to be implemented.



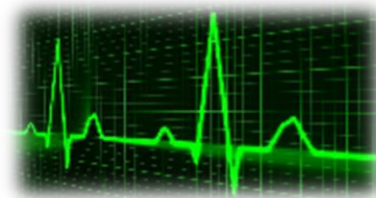
Content of the study

- Common wireless (radio) technologies
- Wireless applications in nuclear
- Wireless applications in other industries
- Final considerations: To use or not to use wireless in nuclear?



Wireless technologies - categories

- Audio-visual communication
- Surveillance
- Monitoring and control
- Large data transfers?



Wireless technologies overview

- 2G/3G/4G Cellular Networks
- 5G Networks
- Satellite communications
- TETRA
- DECT
- Wireless sensor networks
- WLAN
- WMAN/WiMAX
- Ultra-WideBand, UWB
- Location, identification and presence
- Low frequency Wireless Technologies
- Wireless power
- Other wireless technologies
- Evolution of wireless networks

- Wireless Personal Area Network (WPAN)
- Bluetooth
- Zigbee
- LoRa
- WirelessHART
- ISA 100.11a

- Radio Frequency Identification, RFID
- Near Field Communication, NFC
- Satellite positioning
- Pseudolites

- Visible Light Communication (VLC)
- Infrared communication (IrDA)
- Audio communication

Wireless in nuclear

- Regulatory requirements and restrictions
- Wireless in Nuclear & standardization
- Wireless concerns in the Nuclear Power Plants (NPP)
- Wireless in Nordic NPPs
- Wireless in NPPs outside of Nordics



Regulation, standardization



- In the Nordic countries approach has been similar
 - No wireless in the safety critical systems allowed
 - Other areas it could be used but due consideration required
 - Applies both the old and yhe new plants
- In U.S.
 - Same restriction in safety critical systems as in Nordics
 - However active research on possibilities of wireless in nuclear has been done
- IEC and IAEA both active in wireless for nuclear for standard and guidelines.
- Several research studies and pilots already implemented.

Nuclear power reactors in the world

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- A faint, light gray world map is visible in the background of the slide, centered behind the text.
- According to the IAEA's nuclear power reactors in the world (2017) report, there are (as of 31st of Dec. 2016)
 - 448 operational,
 - 61 under construction
 - 80 planned
 - nuclear reactors globally
 - According to IAEA already as of June 2007 globally
 - ~ 25% of the NPPs had been in operation more than 30 years
 - ~ 70% more than 20 years.

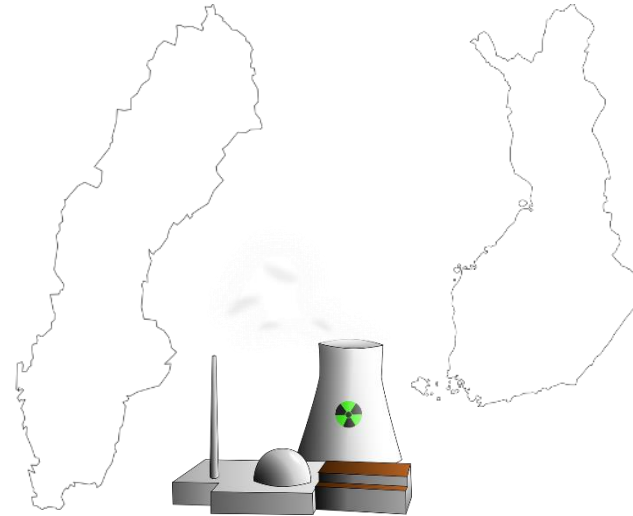
Nordic Nuclear Reactors

Country	Operational	Op. started	Construction	Planned
Finland	Loviisa 1,2 Olkiluoto 1,2	1977 – 1982	Olkiluoto 3	Hanhikivi 1
Total# FI	4		1	1
Sweden	Forsmark 1,2,3 Oskarshamn 1,2,3 Ringhals 1,2,3,4	1971 – 1985		
Total# SWE	10			
Total# Nordic	14		1	1



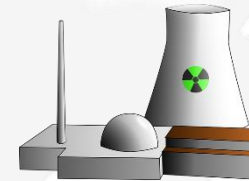
Wireless in Nordic reactors

- **Not used – yet!**
- Audio(-visual) communication
 - DECT, TETRA
- Surveillance
 - RFID, TETRA SDS
- Monitoring and control
 - Remote controlled cranes, perimeter radiation monitoring, ...
- Other wireless usage
 - Outside of the plant – in offices modern office systems
- Future wishes for wireless



Some wireless example cases globally in NPPs

- Wireless Technologies in NPPs using cognitive radio system
- Wireless sensor network trials in Comanche Peak Nuclear Power Plant and Arkansas Nuclear One (ANO) power generating station
- Research project for the U.S. Department of Energy
- Wireless radiation monitoring
- Seismic Monitoring System for Nuclear Power Plants
- Ultra Wide Band (UWB) transmission pilot at the MIT research reactor
- Pilot for a NPP Wireless emergency response system (ERS)
- WSN for Temperature and Humidity Monitoring in a Nuclear Facility at Sadhana loop, India
- EPRI project - Distributed antenna systems in NPPs Catawba Nuclear Station U.S.
- IAEA CRP project - Application of Wireless Technologies in Nuclear Power Plant Instrumentation and Control Systems
- Emerging ICON-project - Design of a wireless nuclear control system, UK
- Nuclear decommissioning - Wireless applications in Sellafield and Magnox UK
- Use of robotic techniques in NPPs



Wireless in other industries (non-nuclear)

■ DOMAINS

- Transport and logistics
 - Maritime, Aviation, Land
- Healthcare
- Industry, factories
- Energy
- Smart Cities
- Environment
- Agriculture
- Mining industry
- Emergency
- Military
- Office, home & consumer



■ WIRELESS EXAMPLE CASES


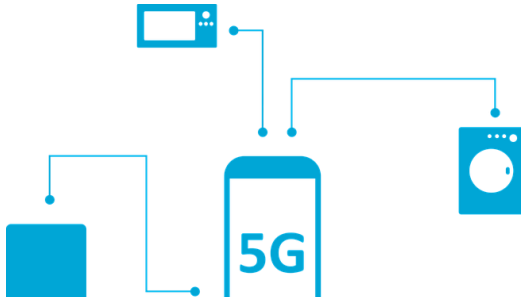
- Machine health monitoring
- Basic process control
- Monitoring of well heads
- Remote process monitoring
- Leak detection monitoring
- Diagnosis of field devices
- Condition monitoring of equipment
- Environmental monitoring
- Tank level monitoring
- Gas detection
- Fuel tank gauging
- Steam trap monitoring
- Open loop control
- Stranded data capture

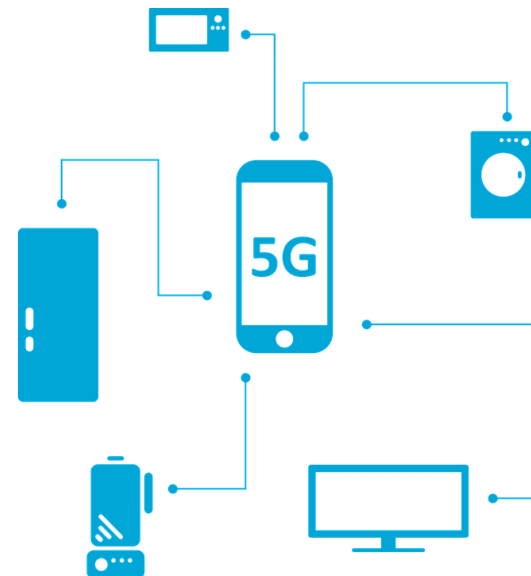
Examples of individual wireless cases in non-nuclear industry

- Wireless instrumentation network on the Gudrun platform
- MoDeRn2020 research project for repository monitoring programme
- Wireless in Steel, driverless stacker trucks and crab cranes at SSAB
- Wireless at various Power Plants
- Conscious Factory - case Nokia



Wireless industrial IoT (IIoT) growing

- Forecasts of IIoT market value and installed units predict rapid growth.
 - Very many vendors offer countless wireless equipment and systems for IIoT.
 - Existing sensor networks have matured
 - Emerging 5G promotes to enable fully mobile and connected society as well as massive scale IIoT with ultra-reliable low latency services.
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- The image contains two illustrations. The top illustration, labeled 'INDUSTRY 4.0', shows a factory with smokestacks and a truck, with a cluster of blue hexagons above it containing icons for various industrial and technological concepts like a lightbulb, gears, a Wi-Fi symbol, and a person. The bottom illustration shows a blue smartphone with '5G' on it, connected by lines to a small tablet, a square sensor-like device, and a washing machine, representing the integration of 5G technology into everyday and industrial life.



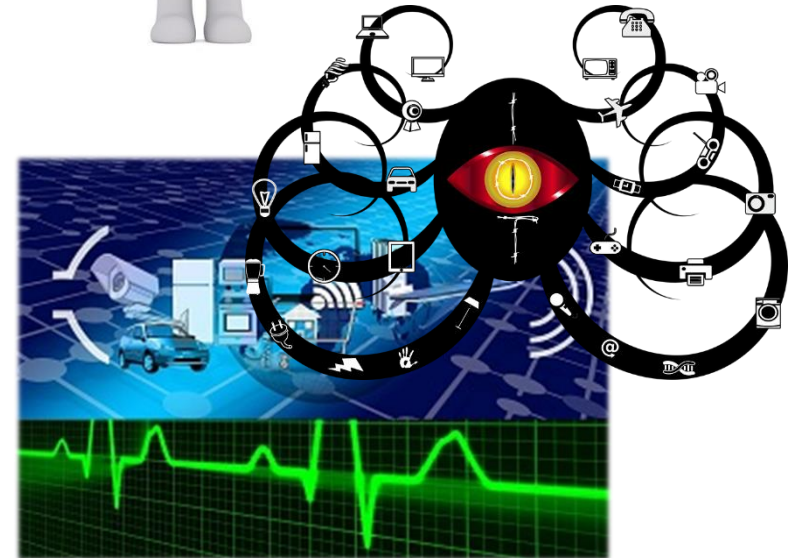
Final considerations

- Reasons not to use wireless in NPPs
- Reasons to use wireless in NPPs
- Proposals for the first wireless steps in (Nordic) NPPs



Disadvantages of wireless issues and countermeasures

- cyber security
- information saturating radiowaves
- eavesdropping
- unauthorized use
- jamming
- difficult planning
- lower reliability
- lower communication speed
- wireless technologies cannot be used
- interference with other NPP systems
- interference with other wireless systems
- energy sources for the wireless devices
- radiation influence



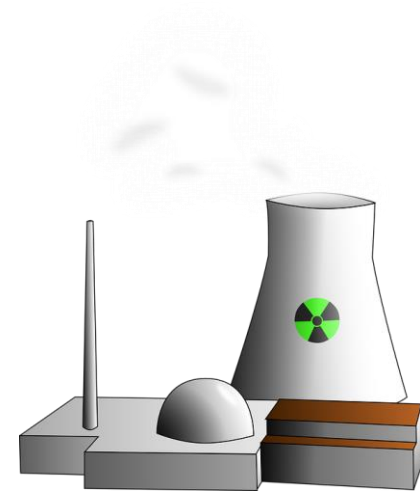
Advantages of wireless

- lower installation costs
- lower maintenance costs
- reduced connector failure
- rapid deployment
- less or no wires
- increased mobility and collaboration
- convenience of use
- better access to information
- easier network expansion
- easier network modifications
- security
- access to difficult locations
- option for guest access
- new operation possibilities



Different NPP phases / operation modes

- Normal operation
- Annual outage
- Service operation before decommission
- Decommission
- Emergency



Proposals for first wireless steps in Nordic NPPs

Wireless application candidate		N	O	S	D	E
1	Wireless infrastructure definition and setup	x	x	x	x	x
2	Radiation monitoring in the perimeter of the plant	x	x	x	x	x
3	Dosimeter monitoring inside the plant	x	x	x	x	x
4	Document and information retrieval	x	x	x	x	x
5	Augmented reality (AR) / Virtual reality (VR) applications for maintenance	x	x	x	x	x
6	Movable temporary measurement systems for selected sensors and equipment	o	x	x	x	x
7	Fixed short range measurements to demanding places	x	x	x	x	x
8	Movable wireless cameras	x	x	x	x	x
9	Visual drone inspections	o	x	x	x	x
10	Drone inspections with carry on sensors	o	o	x	x	x
11	Remotely operated robots with carry on sensors	o	o	o	x	x
		x - applicable				
		o - optionally applicable				

N = normal operation
 O = Annual outage
 S = Service before decommission
 D = Decommission
 E = Emergency

Final conclusion

- Wireless has been adopted into use in the other industries
- Wireless is also on the way in to the NPPs





TECHNOLOGY «FOR» BUSINESS

