Wireless Communications for Future Manufacturing Field ~Flexible Factory Project~

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FLEXIBLE FACTORY PROJECT

Smart Resource Flow

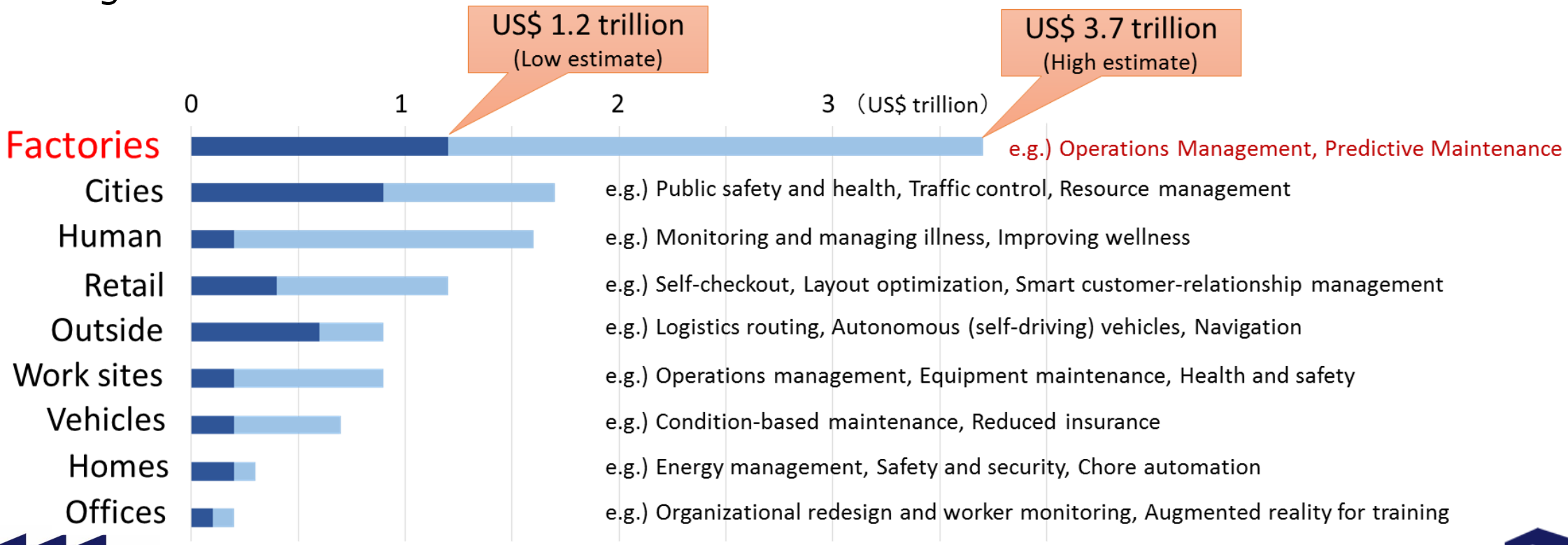
Today's Talk

- **Wireless Communications and Manufacturing**
- **In the manufacturing field**
  - Problems of wireless communications
  - Needs of wireless communications
- **Toward Flexible Factory**

Potential economic impact by IoT @2025

■Information Gathering for Solution of Problems

・Workforce and skilled workers shortage, High-mix low-volume production , Change of value chain



Source: McKinsey Global Institute Report

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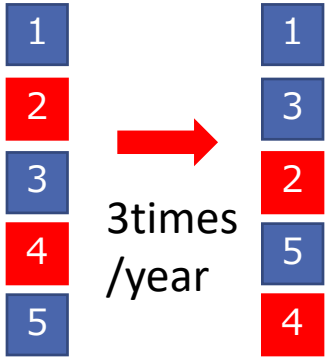
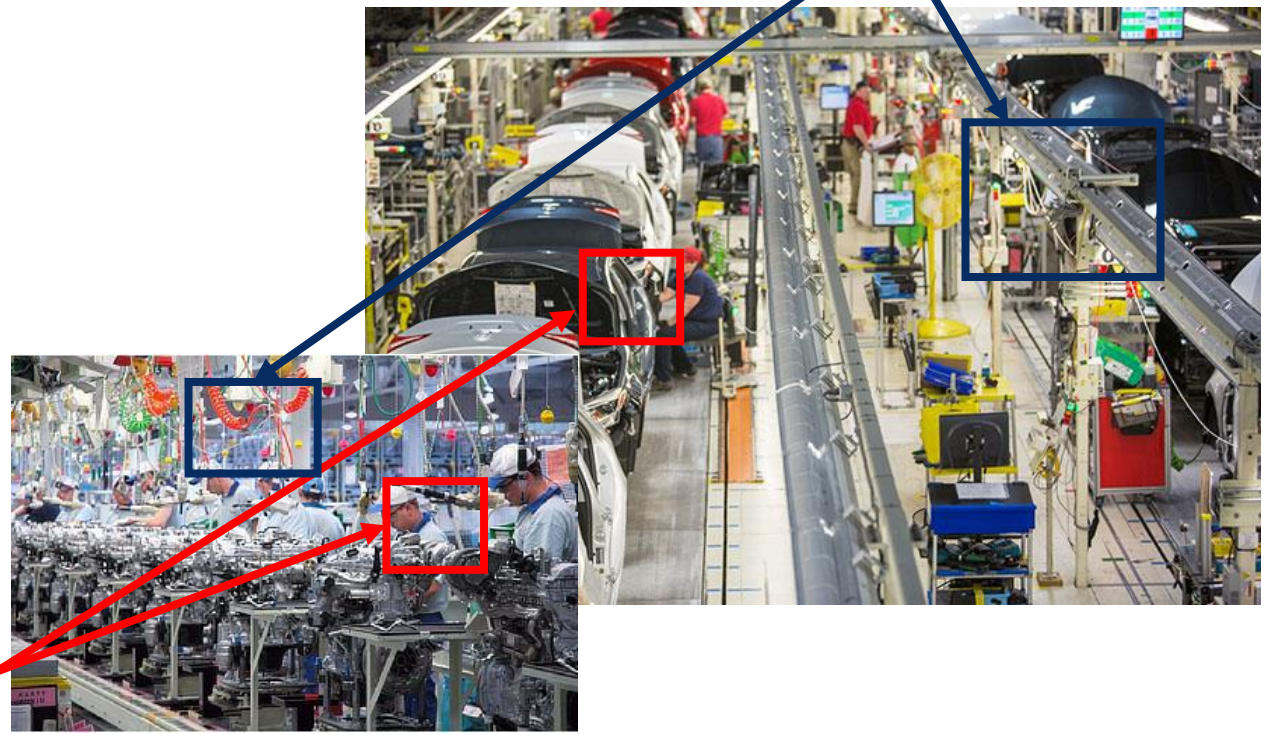
Reconfiguration of production line

- **Inspection process in the production line**



Change sequence of systems

Future usage of wireless communications



The assembling tool has a role of inspection machine

Current usage of wireless communications

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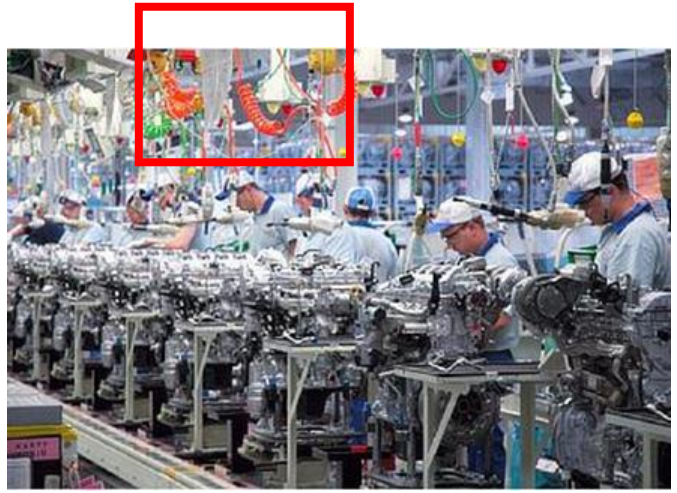
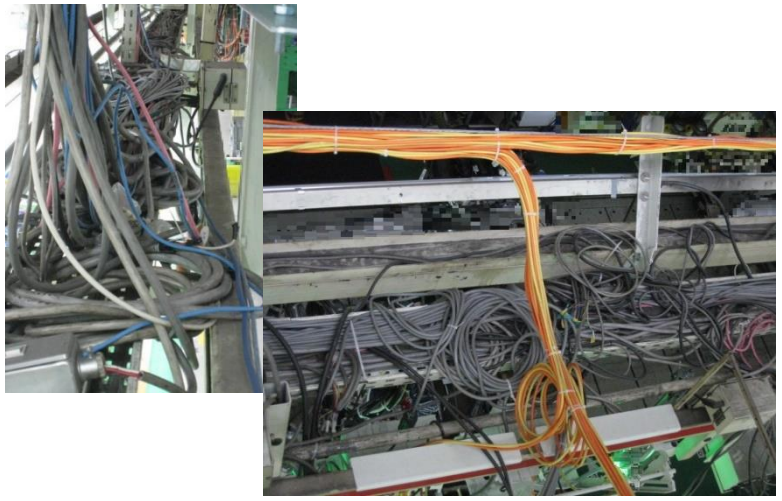
Why not wired?

Disconnected ！ ？



Messy!!!!



Information has to deliver right place.

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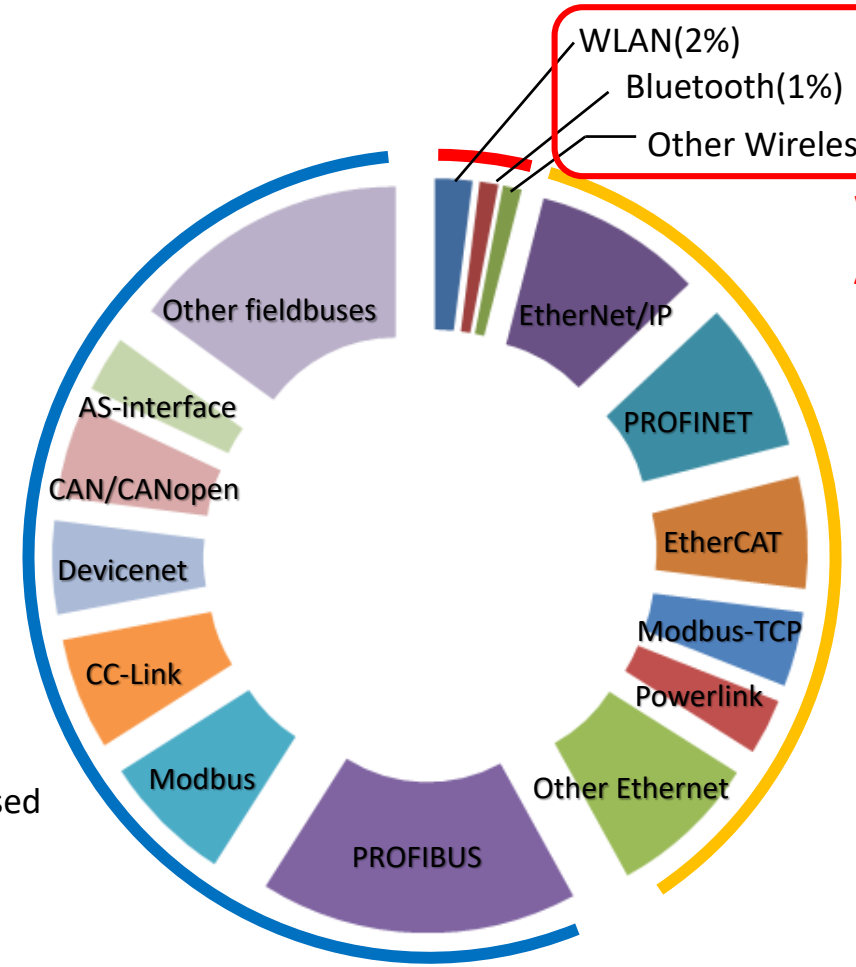
Communication Nodes for Factory Automation

Share of wireless nodes is 4%, but is increasing at an annual growth rate of 30%.



Wireless 4%
Annual growth 30%

Fieldbus 58%
Annual growth 7%

Industrial
Internet 38%
Annual growth 20%

HMS's estimation for 2016 based on number of new installed nodes in 2015 within Factory Automation.

Source http://www.automationinside.com/2016/03/industrial-network-market-shares-2016.html

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Independent Wireless Systems

Step-by-step installation for each equipment or process flow resulting in complexity with independent wireless systems.

- Standard-compliant wireless systems using ISM or globally available frequency-bands.
- Non-standard wireless systems.
- Small-power specified wireless systems.

Industry specific and applicable wireless standards

Frequency Band	Industry specific	Industry applicable
920MHz		Wi-SUN SIGFOX LoRa Wi-Fi/HaLow
2.4GHz	WirelessHART ISA100.11a WSAN	Wi-Fi Bluetooth, BLE Zigbee
5GHz		Wi-Fi
60GHz		Wi-Fi/WiGig

What is most important thing?

- Top priority issues in the manufacturing field are…
  - **Productivity**
  - **Quality**
  - **Security**

Of course, they are most important for introduction of Wireless Communications!

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Flexible Factory Project

Efforts to solve real problems in the manufacturing fields.

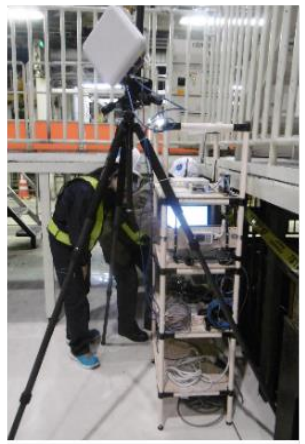
- Revealing crucial requirements for wireless communications.
- Conducting wireless environment evaluation and wireless packet transmission tests at factories in operation.

Collaborating work since 2015

- Participants:
  - NICT
  - OMRON
  - ATR
  - NEC
  - NEC Communication Systems
  - FUJITSU
  - FUJITSU KANSAI-CHUBU NET-TECH
  - Mobile Techno
  - Sanritz Automation
  - MURATA MACHINERY
- Partners: 7 factories of 5 companies







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Challenges for Wireless Utilization in Factories

Dynamic Wireless Environment Change

- Motions of materials, parts, products, and carriers in a closed space. — msec to sec
- Retooling, equipment changeover, and system on/off. — hours to days
- Layout reconfiguration, and production-line installation. — months to years

Diverse Wireless Environment

- Depending on scale of the facilities, existence of obstacles for radio propagation, noises, and the number of deployed wireless systems.

Independent Wireless Systems

- Step-by-step installation for each equipment or process flow.
- Coexistence of heterogeneous and legacy devices/systems.

Flexibility is a key to address the issues.

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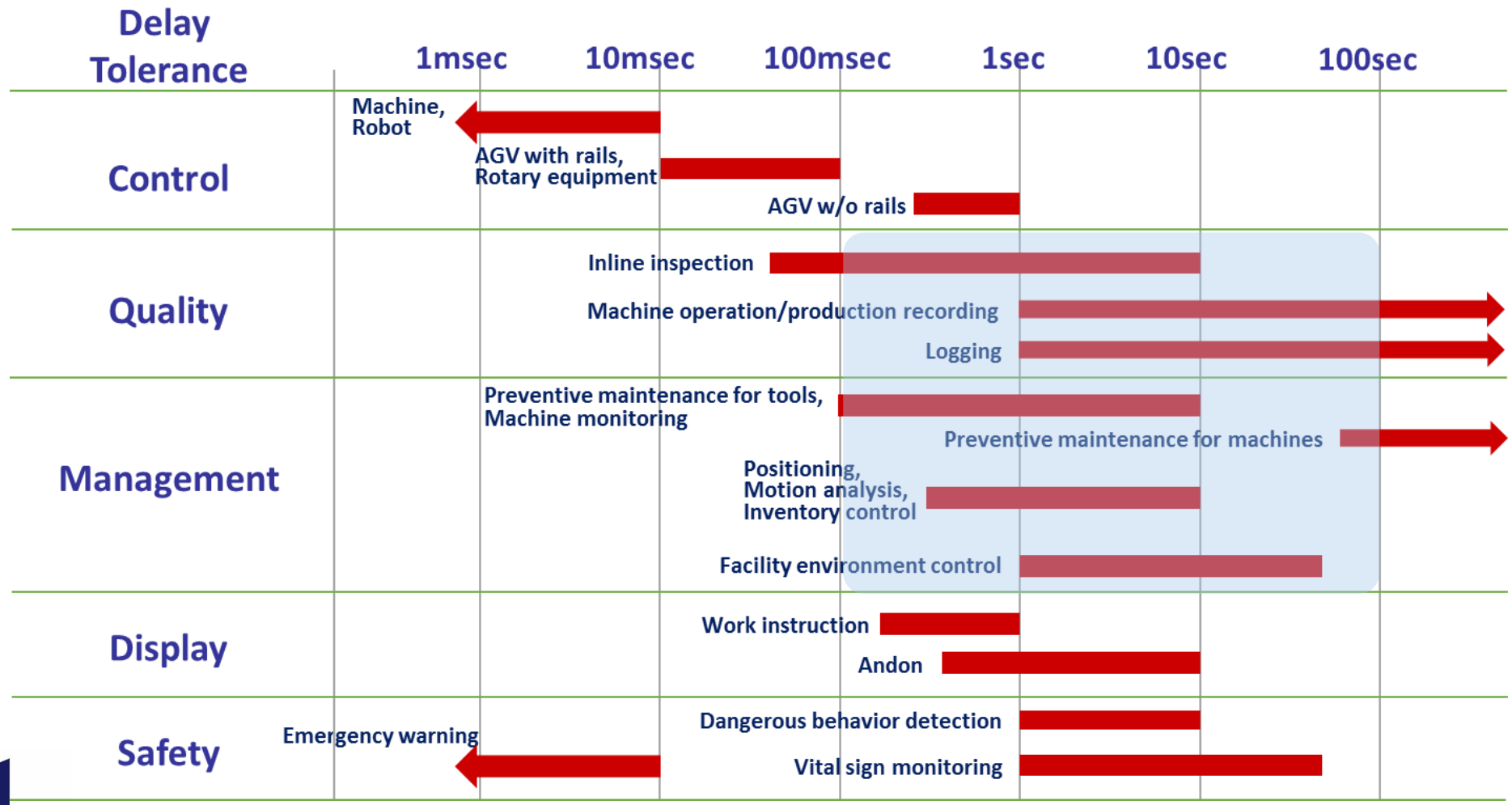
Delay tolerance



Source: Flexible Factory Project

Diverse Wireless Environment

1. Location
2. Scale of the facility
3. Obstacles for radio propagation
4. Machine noise in microwave frequency
5. Evolutional stage for wireless utilization

List of Evaluated Factories in Operation

Factory #	Process	Scale	Residential Areas	Shielding Objects	Noise from Machines	Unwire Stage
1	Printed circuit board assembly	Small	Near	No	No	②
2	Large-machine assembly	Large	Isolated	Yes	No	③
3	Large-machine assembly	Large	Isolated	Yes	No	②
4	Large-machine assembly (same as #2, measured half year later)	Large	Isolated	Yes	No	③
5	Printed circuit board assembly	Medium	Isolated	No	No	②
6	Large-metal mold casting	Large	Isolated	Yes	Yes	①
7	Large-metal	Large	Isolated	Yes	Yes	②
8	Large-metal processing(same as #7)	Large	Isolated	Yes	Yes	②
9	Large-metal processing(same as #7)	Large	Isolated	Yes	Yes	②
10	Large-machine assembly (same as #2, measured 1.5 year later)	Large	Isolated	Yes	No	③
11	Large-metal press	Large	Isolated	Yes	Yes	①
12	Large-metal welding	Large	Isolated	Yes	Yes	①
13	Printed circuit board assembly	Large	Isolated	No	No	②
14	Steel works	Large	Isolated	Yes	Yes	
15	Food Manufacturing	Large	Isolated			
16	Medium-size metal parts assembly	Large	Isolated	Yes	No	
17	Medium/large-metal forging	Large	Isolated	Yes	Yes	

Done

Scheduled

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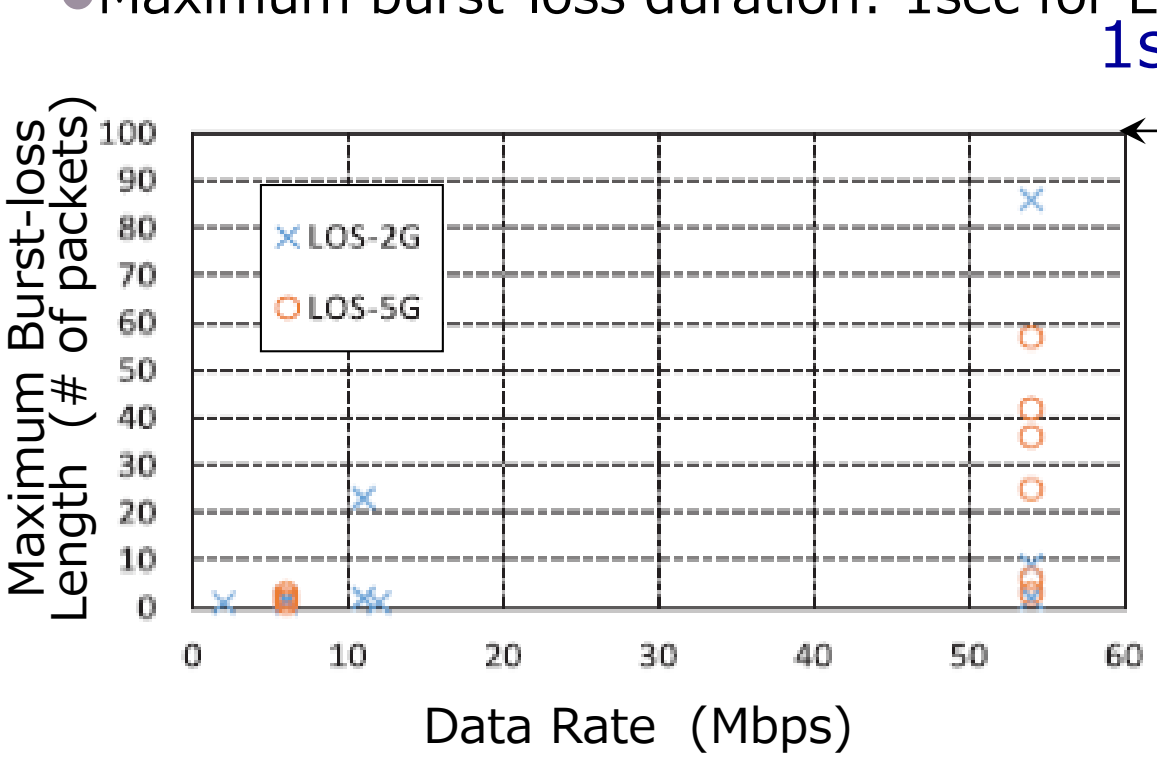
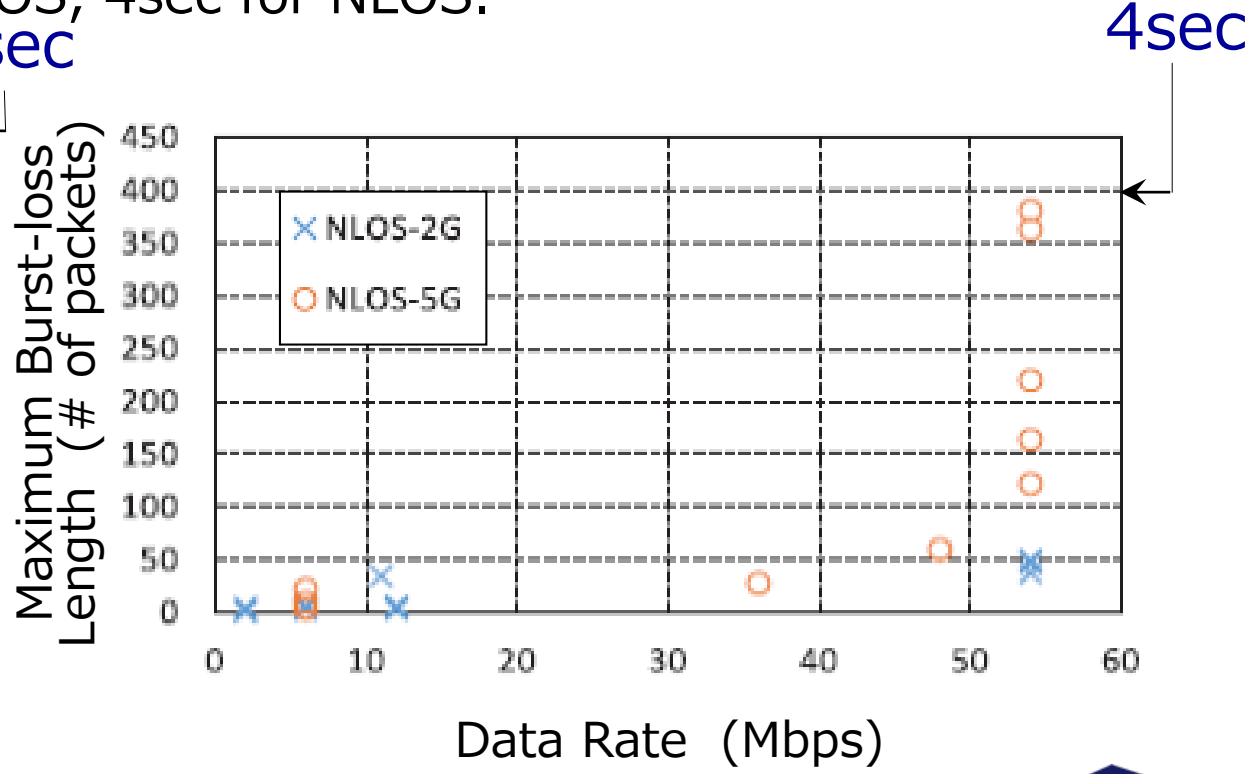
Burst Loss in the Factory

Long burst-loss observed at higher data rates.

- Significant loss measured at 54Mbps for 2.4/5GHz (IEEE802.11g).
- Maximum burst-loss duration: 1sec for LOS, 4sec for NLOS.



Maximum Burst-loss Length (LOS)



Maximum Burst-loss Length (NLOS)

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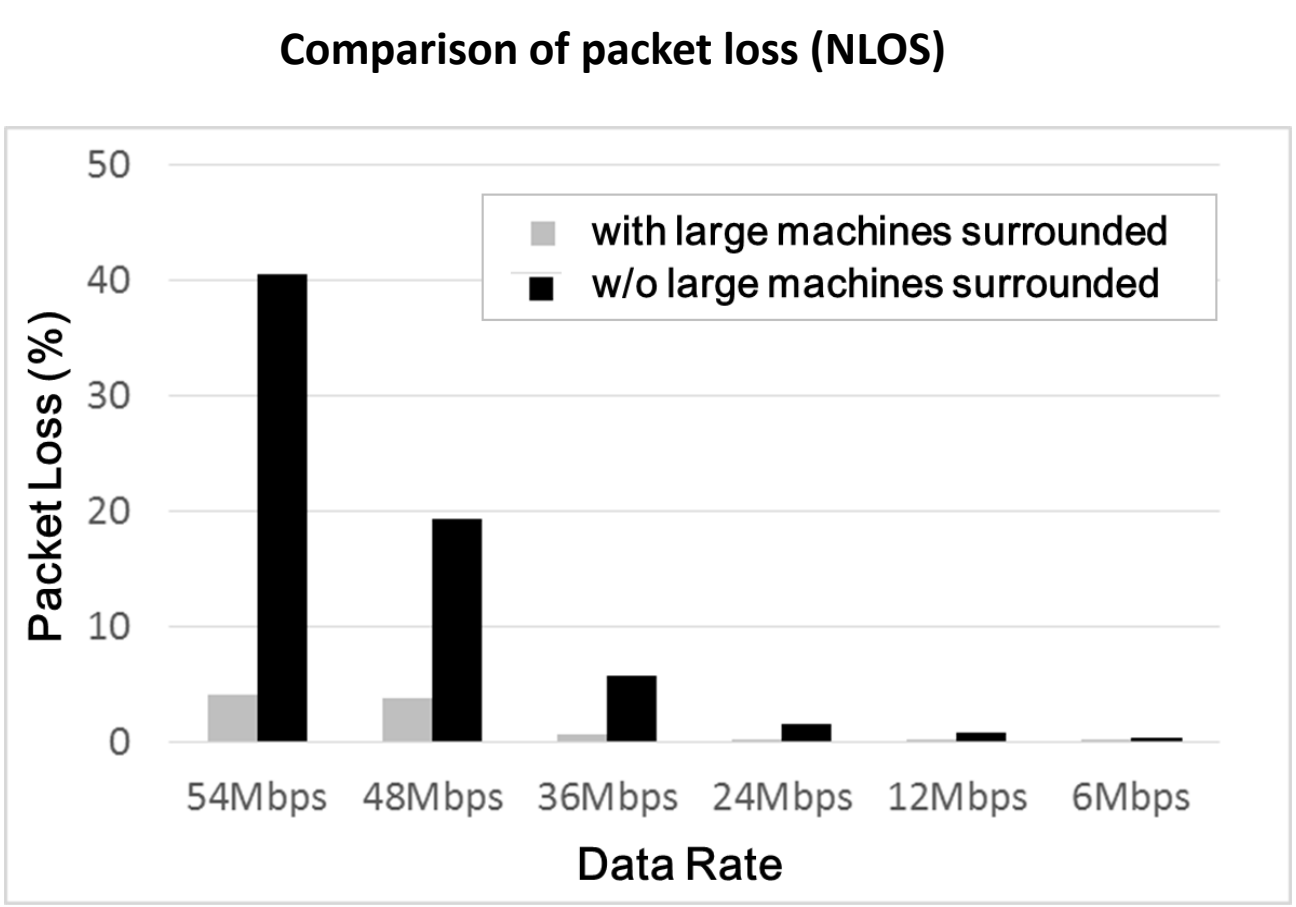
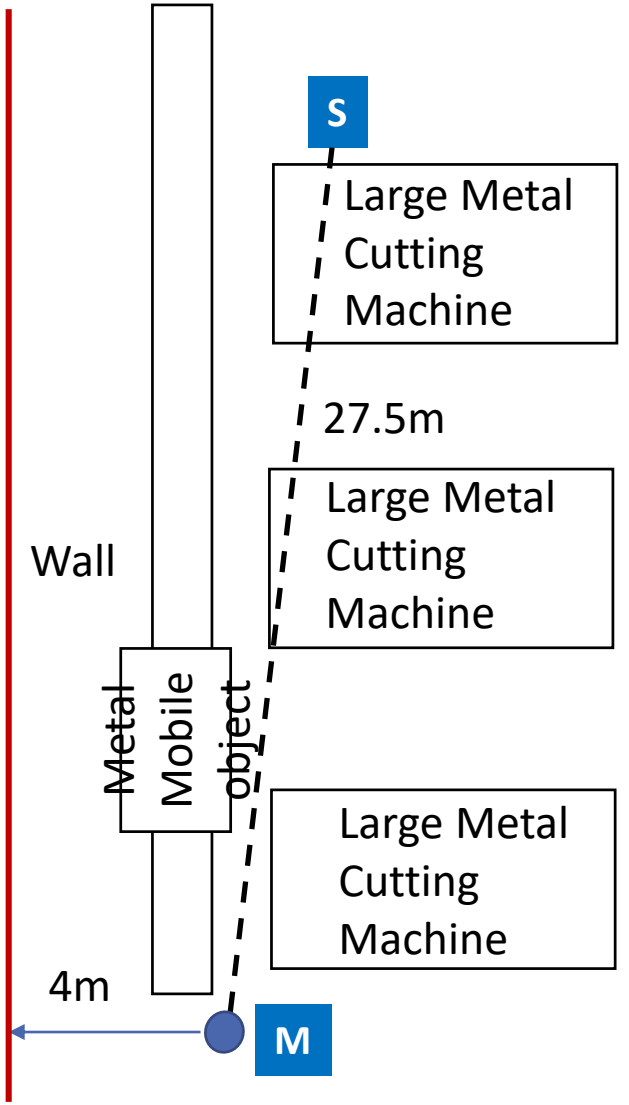
Effect of metal for wireless communications





S:Slave

M:Master

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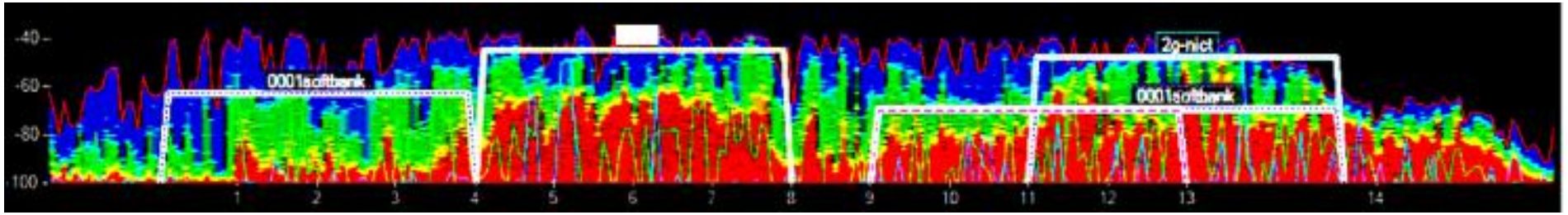
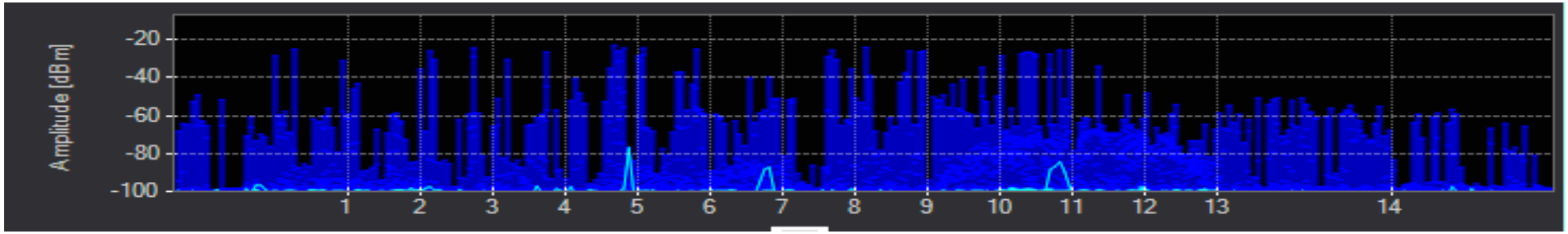
Noises in Factories

External and internal noises at 2.4GHz

- Wi-Fi access points placed in residential area near the factory.
- Inverters of motors in equipment in the factory.



Factory for printed circuit board assembly near residential area



Factory for large-metal mold casting

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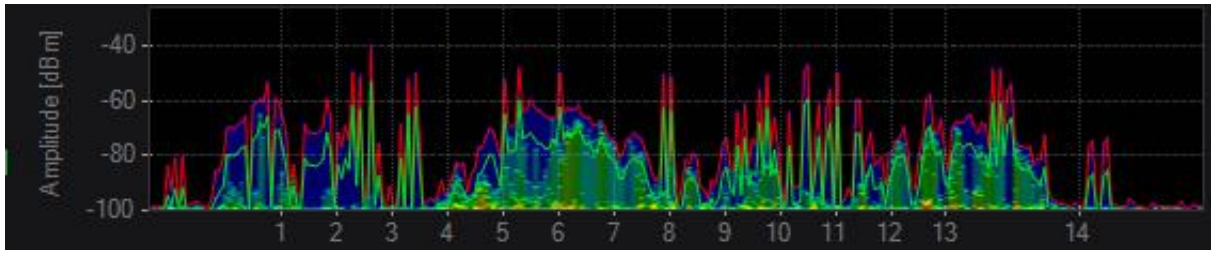
Mix Heterogeneous Systems

- Sequence of introduction of wireless communications
  - Switch, remote controller, RF-ID tag etc. (not control)
  - Use 2.4 GHz band



Factory of Large Metal Process（2016/02)

- Past: Automatic Guided Vehicle (AGV) using 5GHz wi-fi (about interference of other systems of 2.4GHz)
- Now: ICT infrastructure also use 5GHz wi-fi→Battle

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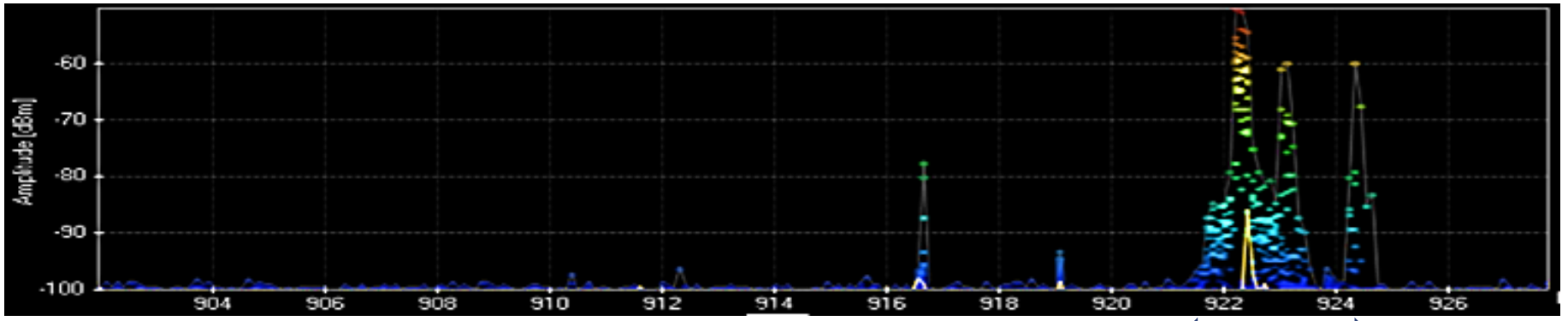
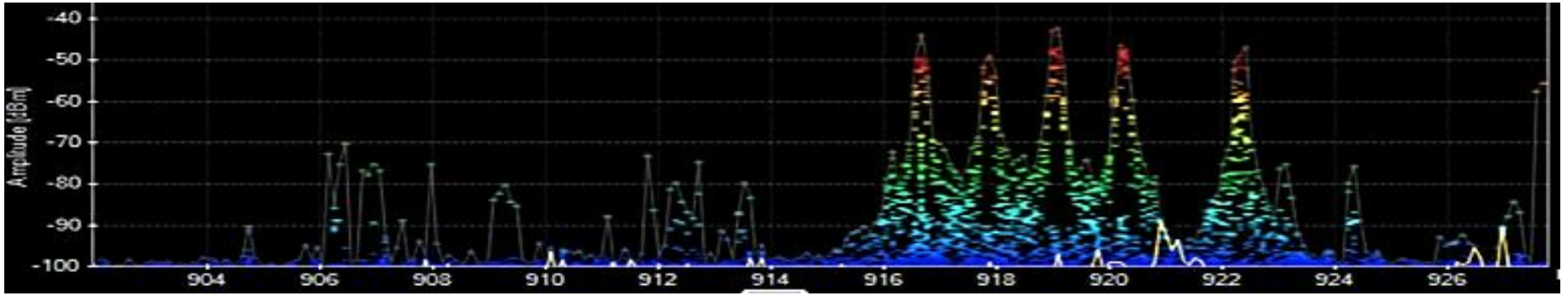
Dynamic Change of Wireless Environment

920MHz



(1) 2015, July

Trial



(2) 2015, Dec.

New System

Operating

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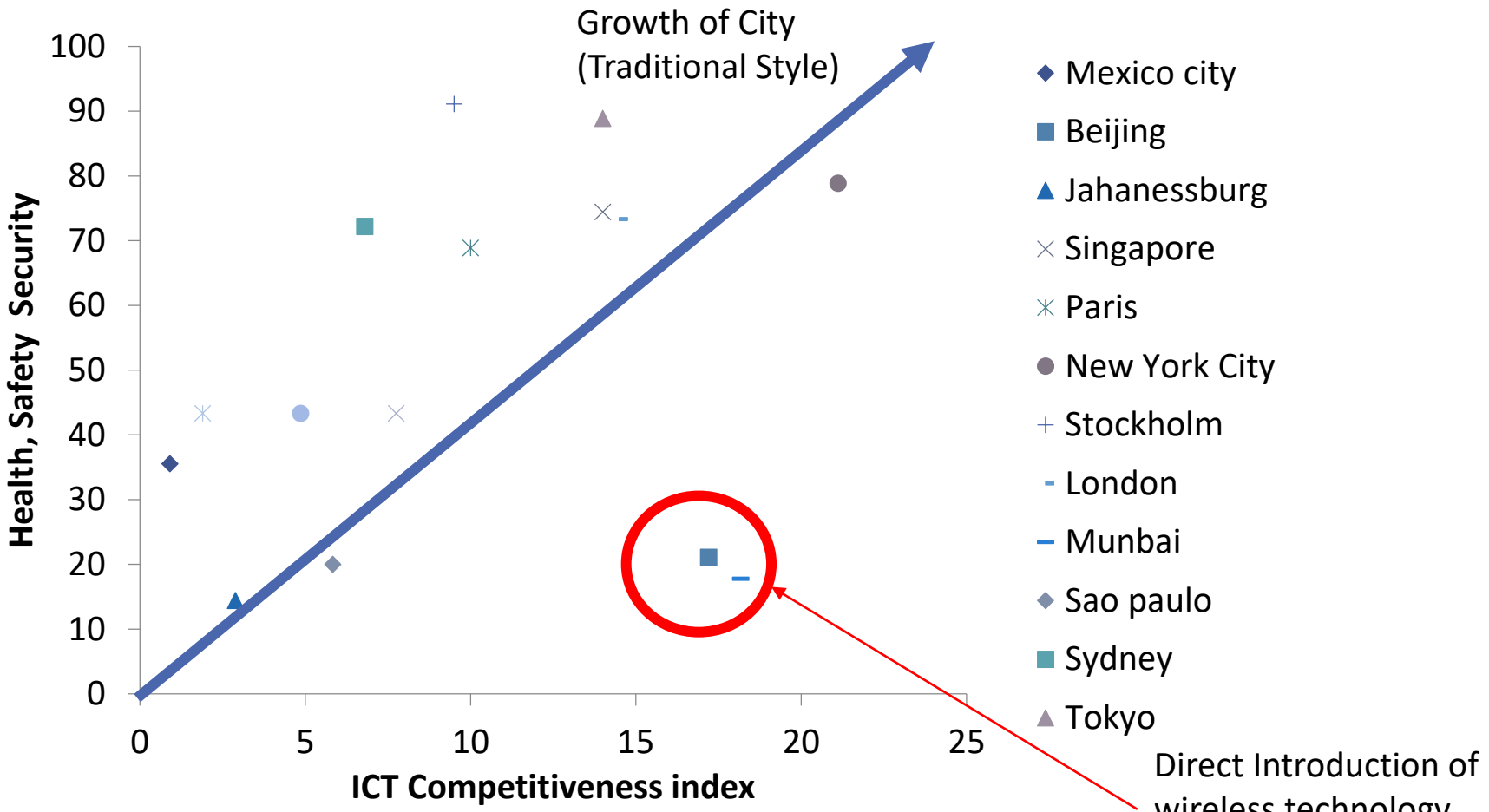
City Infrastructure Glow



PricewaterhouseCoopers, 2013

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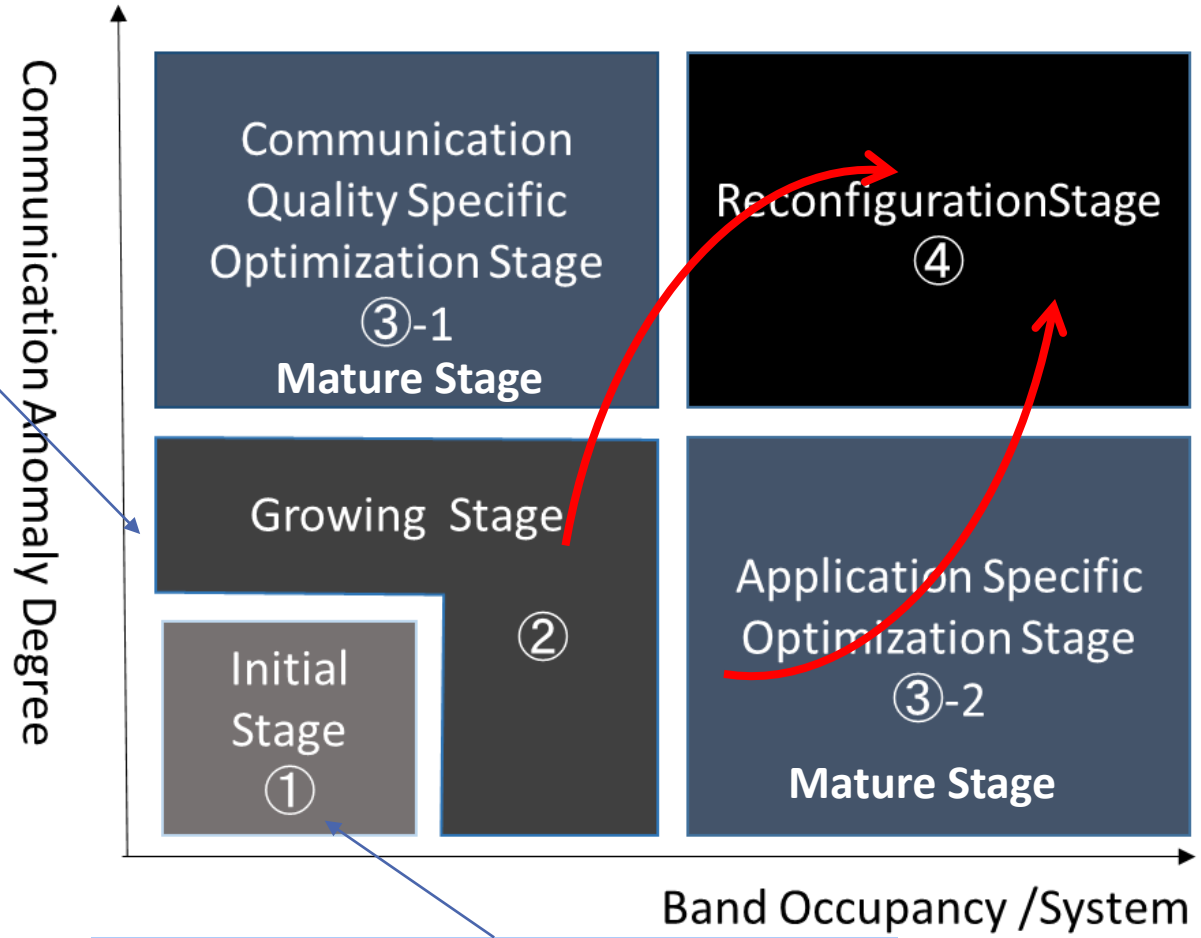
Unwire Stage



several systems (sensing systems and RF-ID etc.)

Inter-company backbone system and IP phone, monitoring data using wireless communications

Data Size is smaller than 50Byte not sensitive about data delivery delay

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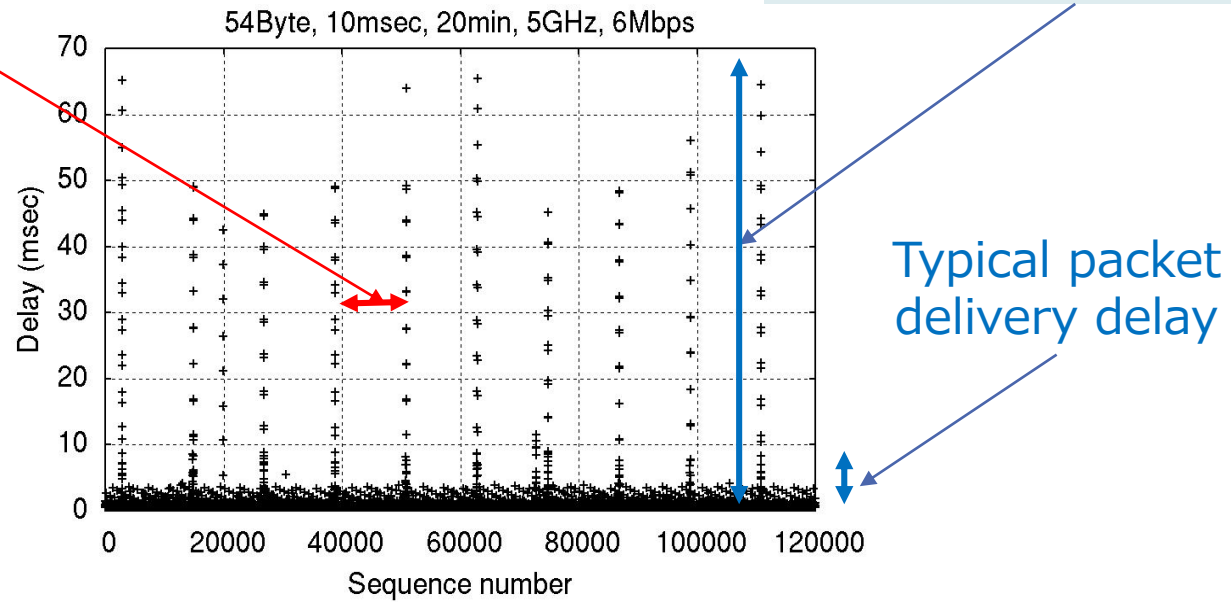
Example of Mature Stage 1
Communication Quality Specific Optimization Stage

Packet delivery delay of channel using Automatic Guided Vehicle (AGV) control

Tact: One unit time of manufacturing line

Long CSMA/CA waiting time: Sending huge number of same data packets



Typical packet delivery delay

Bandwidth are free but high possibility of communication problems

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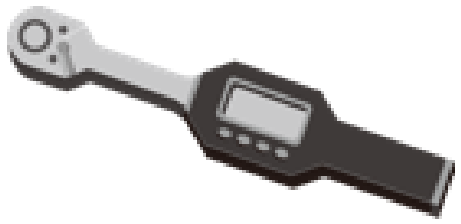
Evolution of manufacturing tools

Now

Small-Volume Data

Wireless Poka-yoke

- Screw Tightening OK
- 20~30Byte*O(1)/O(10)sec
- O(100)sets/line

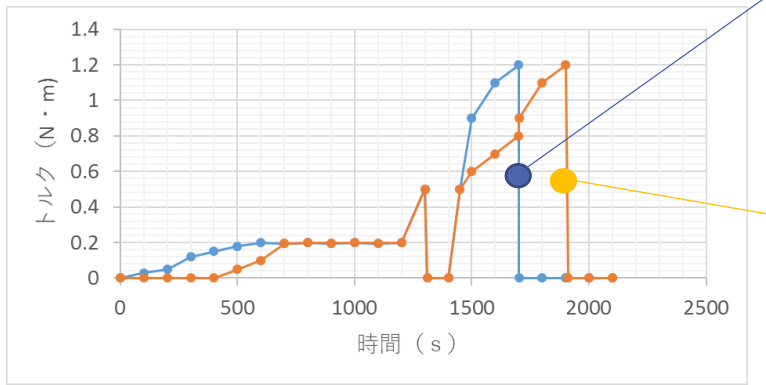


Future

Large-Volume Data

Next Generation Wireless Poka-yoke

- Screw Tightening OK **+ torque waveform**
- (20~30Byte**+20~30Kbyte**)*O(1)/O(10)sec
- O(100)sets/line



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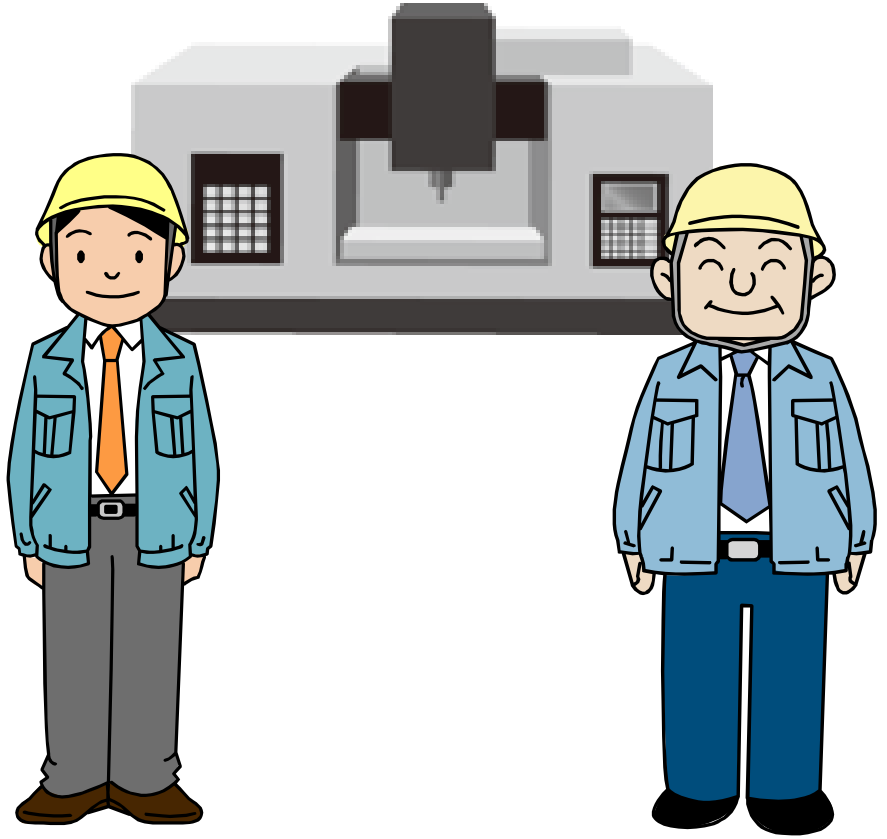
When we will change parts of machine?



The key issue is how to sense the sense of skilled works.

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Example of Mature Stage 2
Application Specific Optimization Stage

- Long term, high frequency, huge data
  ex) Video Stream , waveform data　etc..

Breakdown Maintenance

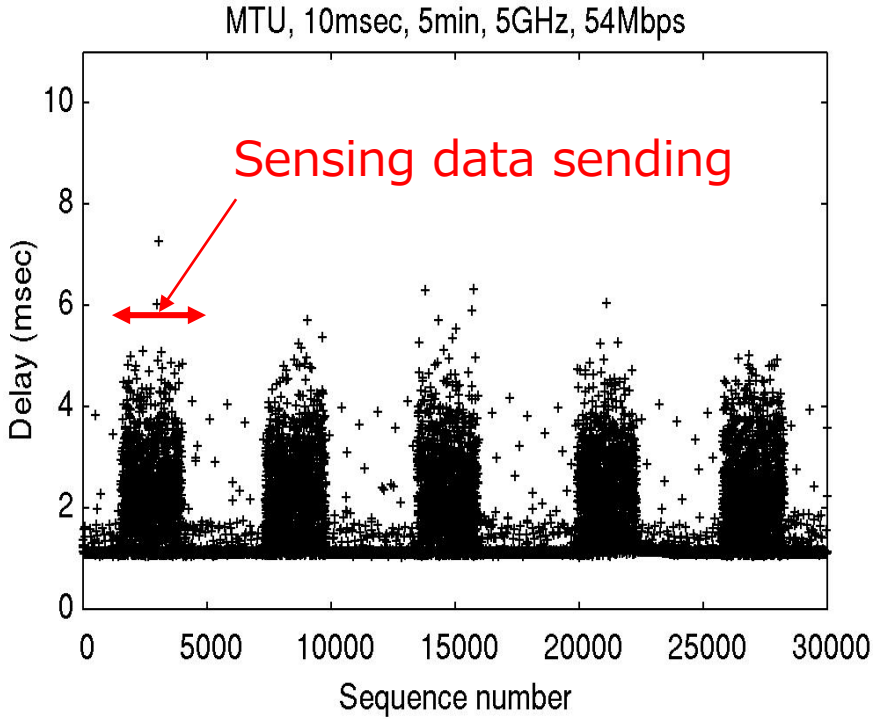
Inspection Maintenance

Time Based Maintenance

Condition Based Maintenance

Corrective Maintenance

Preventive Maintenance



Few applications occupy of bandwidth

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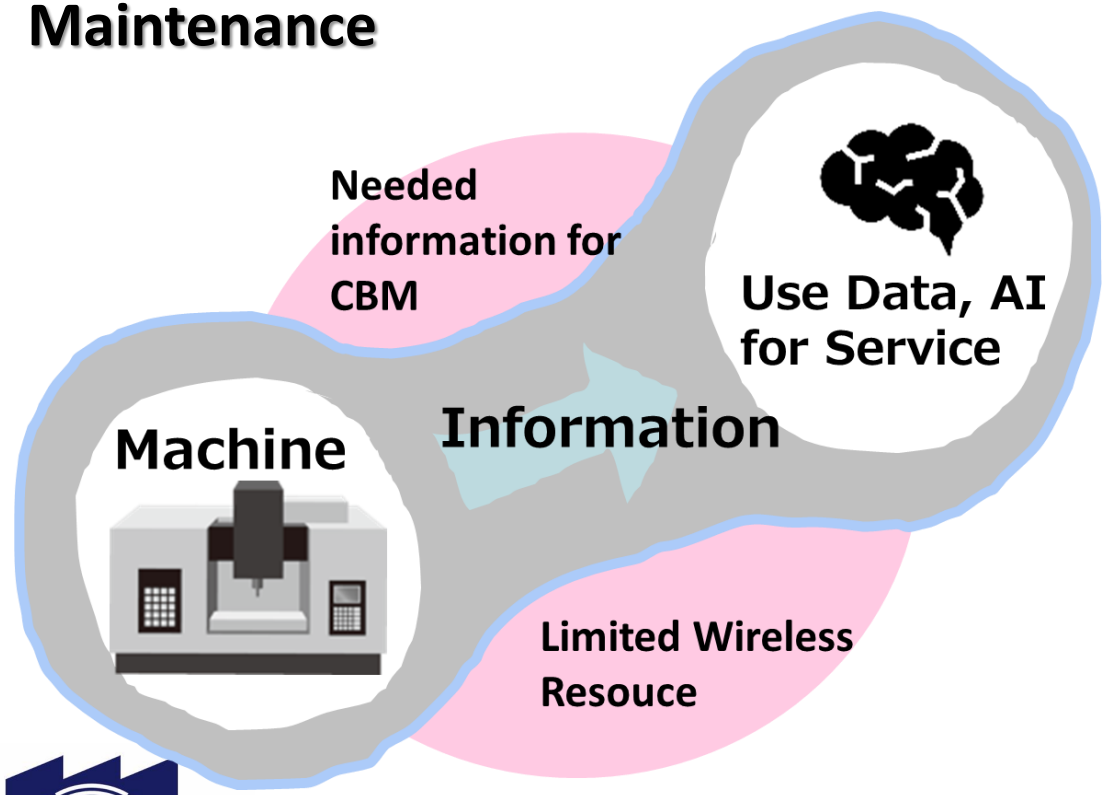
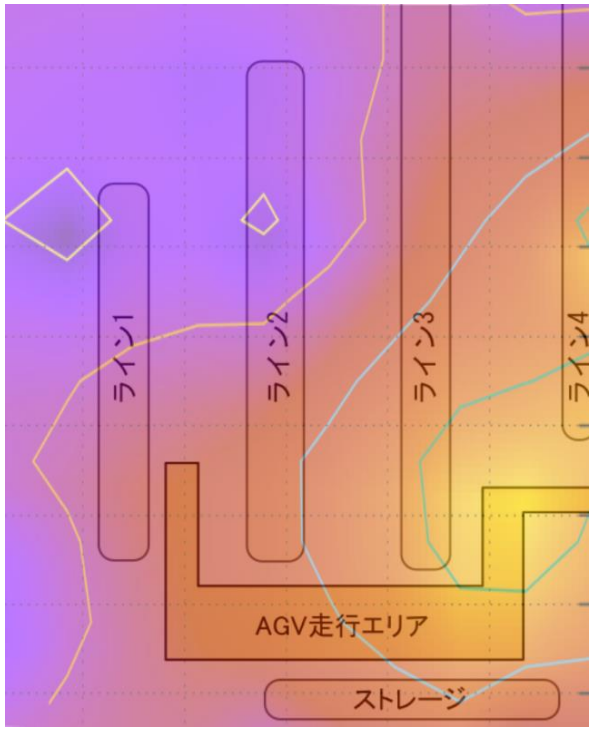
Wireless Communication with AI

- **Definition of the communication requirement for Condition Based Maintenance**



- **Dynamic Communication Management with AI**



Real-time Visualization of Wireless Communications

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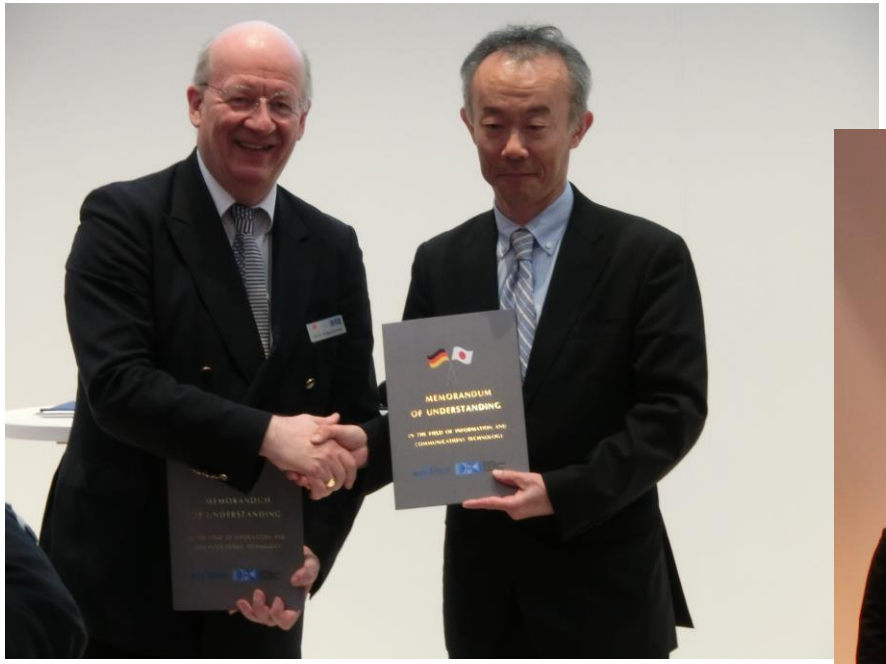
Collaboration with DFKI



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Toward Flexible Factory

- **Wireless communications receive a lot of attentions**

- **Special problems of wireless communications in the manufacturing field**
  - Dynamic wireless environment change
  - Diverse wireless environment
  - Independent wireless systems

- **Make clear**
  - Purpose of application

- **Utilizing limited and fluctuating radio resources**
  - Harmonized over different wireless systems
  - Application-aware coexistence

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Special Thanks

- OMRON Corp.
- Advanced Telecommunications Research Institute International
- NEC Corporation
- NEC Communication System Ltd.
- FUJITSU LMITED
- FUJITSU KANSAI- CHUBU NET-TECH LIMITED
- Mobile Techno Corp.
- Sanritz Automation Co., Ltd.,
- MURATA MACHINERY LTD
- Many factories support our research activity and field experiments.

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