

Wireless Applications and Usage Scenarios for Flexible Factory IoT

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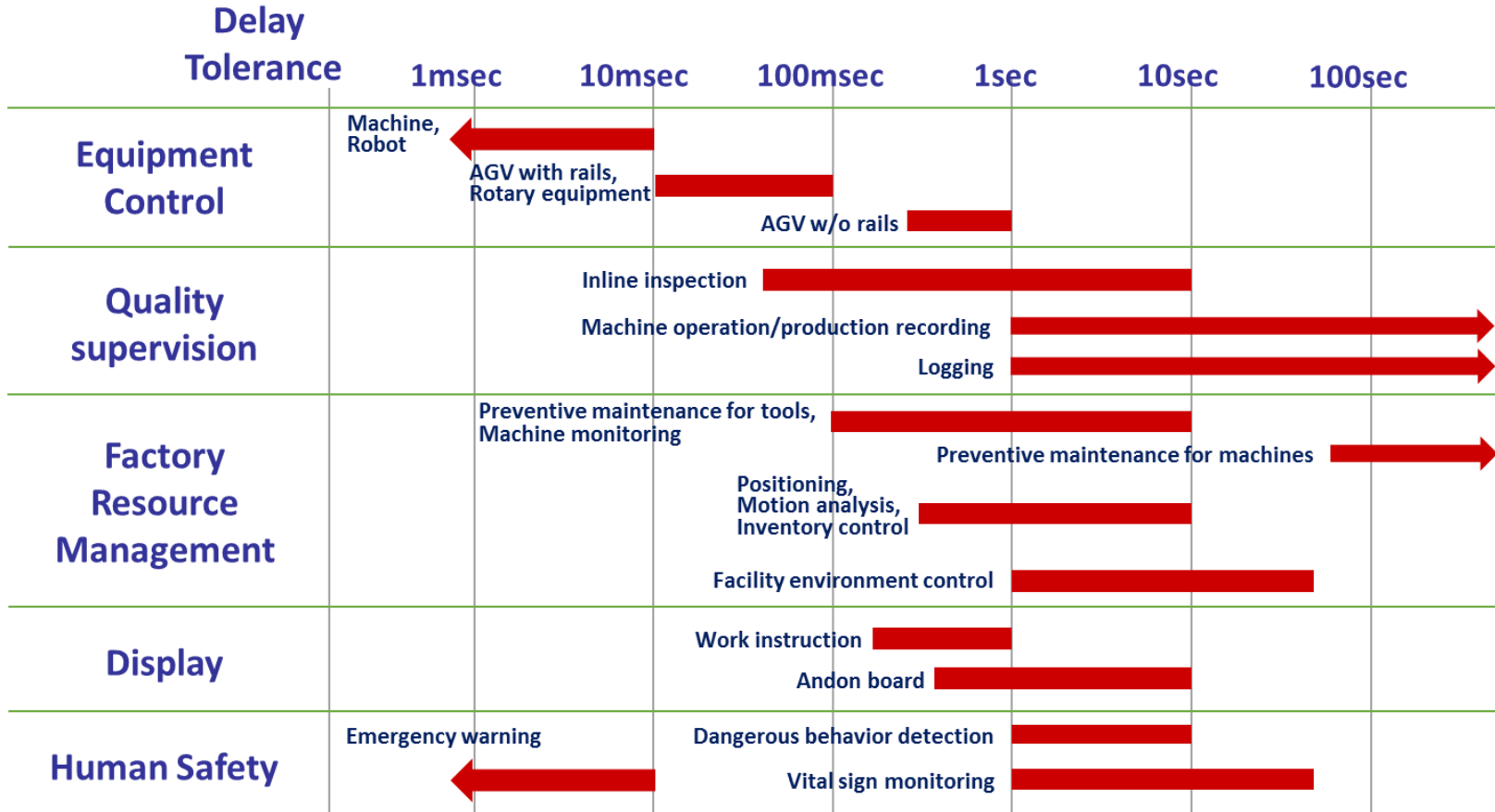
Introduction

- This contribution is to propose contents of wireless applications and usage scenarios for the report of Flexible Factory IoT in NEND.
- Requirements described here are at an application level and will be followed by discussions for a commutation-level requirements after the project starts.

Application categories in factories

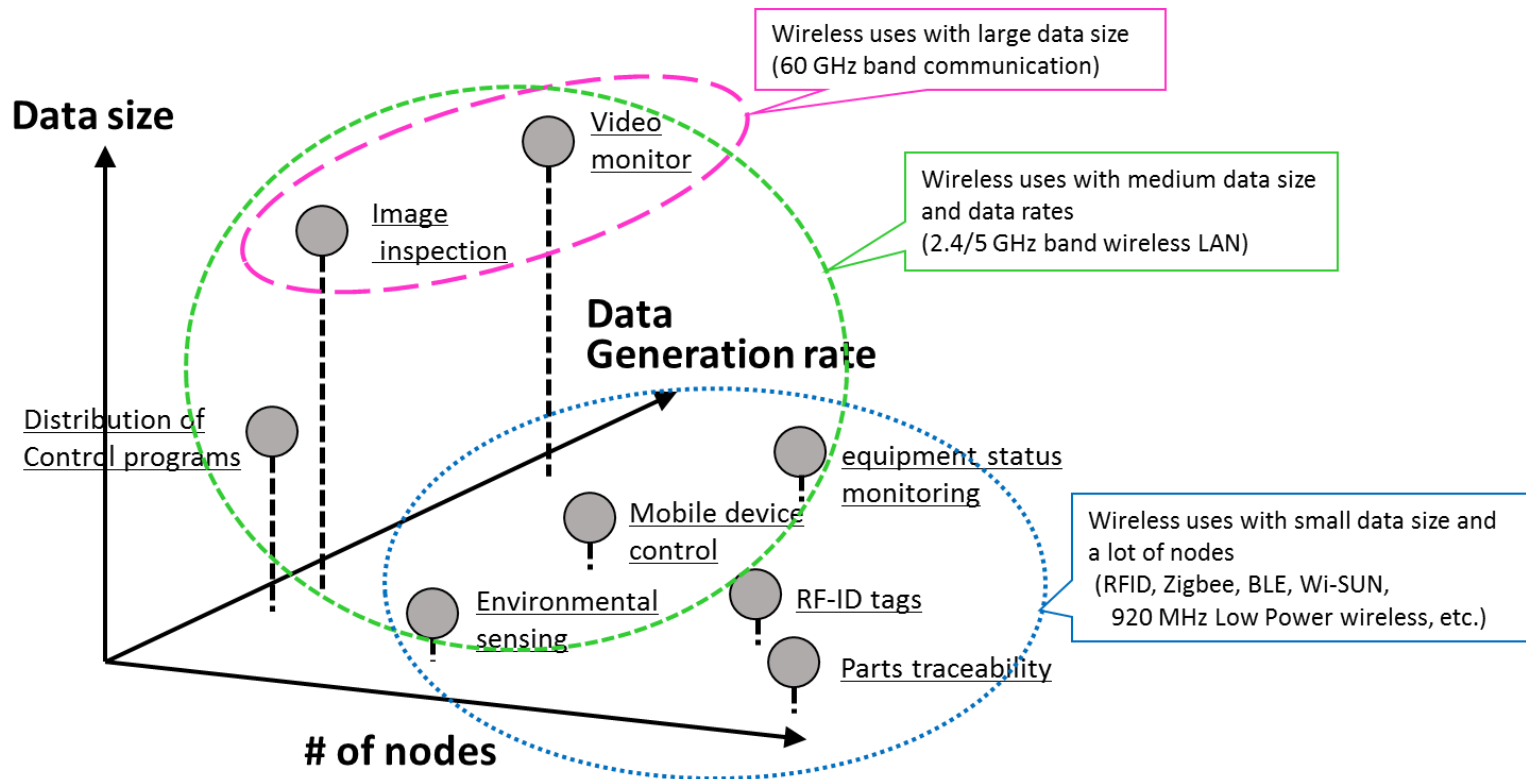
Category	Description	Classification according to the purpose
Equipment Control	sending commands to mobile vehicles, production equipment	(1) Controlling, operating and commanding of production equipment, auxiliary equipment
Quality Supervision	collecting information related to products and states of machines during production	(1) Checking that products are being produced with correct precision (2) Checking that production is proceeding with correct procedure and status
Factory Resource Management	collecting information about whether production is proceeding under proper environmental conditions, and whether personnel and things contributing to productivity enhancement are being managed appropriately	(1) Checking that the production environment is being appropriately managed (2) Monitoring movement of people and things (3) Checking the management status of equipment and materials (stock) (4) Checking that the production equipment is being maintained (5) Appropriate recording of work and production status
Display	For workers, receiving necessary support information, for managers, monitoring the production process and production status	(1) Providing appropriate work support (2) Visually display whether the process is proceeding without congestion or delay (3) Visually display the production status
Human Safety	collecting information about dangers to workers	(1) Ensuring the safety of workers
Other	Communication infrastructure with non-specific purposes	(1) Cases other than the above

Permissible latencies of representative wireless applications



Elements of wireless applications and communication requirements

- Data size, data generation rate (=Communication rate), numbers of nodes/area and delay tolerance are the key elements in the requirements at an application level.



Equipment Control

(1) Control, operation and command of production equipment and related facilities

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
1	control of liquid injection	water volume	64	once per 1 min.	100 msec.	1
2	operation of conveyor control switch	PLC	16	5 per day	100 msec.	5

Quality Supervision

(1) Checking that products are being produced with correct precision

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
3	size inspection by line camera (line sensor)	size measurements	30K	once per sec.	5 sec.	1
4	detect defect state	defect information (video)	500	one per 100 msec.	500 msec.	1
5	detect incorrect operation	anomalous behavior due to adding impurities	1M	once per sec.	10 sec.	1

(2) Checking that manufacture is proceeding with correct procedure and status

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Data Size (bytes)	Communication Rate	Arrival Time Tolerance	Node density (# of terminals per 20m x 20m)
6	sensing for managing air conditioning	air stream	64	once per sec.	1 min.	1
7	monitoring of equipment	state of tools, disposables	a few hundreds	once per sec.	1 sec.	2
8	counting number of failsafe wrench operations	pulses	64	once per 1 min.	100 msec.	10

Factory Resource Management

(1) Checking that the factory environment is being correctly managed

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
9	managing clean room (booth)dust count	Dust count (particles)	32	once per min.	5 sec.	5
10	managing carbon dioxide concentration	CO2 concentration	16	once per min.	5 sec.	2
11	preventive maintenance	machine's temperature	a few tens	real-time	1 sec.	

(2) Monitoring movement of people and things

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
12	movement analysis	wireless beacon	a few tens	twice per sec.	few secs.	
13	measuring location of people and things	transmission time (phase), radio signal strength, etc.	a few tens of thousands	once per sec.	1 sec.	2
14	measuring location of products	location of products during manufacture	200	once per sec.	1 sec.	20

Factory Resource Management (Cont'd)

(3) Checking that equipment and materials (stock) are correctly managed

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
15	tracking assets (beacon transmission)	information of equipment and things	200	once per sec.	1 sec.	20
16	tracking parts, stock	RFID tag	1K	1~10 times per 30 mins.	100 msec.	3 to 30

(4) Checking that production equipment are being correctly maintained

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
17	managing facilities	activity of PLC	4K	once per sec. ~ once per min.	one ~ few tens of secs.	
18	measuring energy consumption	energy, current	64	once per min.	1 min.	1
19	monitoring revolving warning light	defect information	100	few times per hour	10 sec.	25

Factory Resource Management (Cont'd)

(5) Checking that work and production status are being correctly logged

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
20	work record	text data	100	once per min.	1 sec.	9
21	work proof	certification data	1K	once per 3 hours	10 sec.	9
22	Checking completion of process	image, torque waveform	100~100K	once per 10 secs. ~ 1 min.	1 sec.	5

Display

(1) Providing appropriate work support

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
23	work commands (wearable device)	image	600	once per 10 secs. ~ 1 min.	1~10 sec.	10 to 20
24	view work manual	text data	100	once per hour	10 sec.	9
25	display information (image display)	image (video/still image)	5M	once per 10 secs. ~ 1 min.	few sec.	

(2) Visualization showing process is proceeding without delay

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
26	managing congestion	counter (number or remaining number)	few bytes	once per 10 secs. ~ 1 min.	few sec.	
27	managing operation activity	activity of PLC	128	once per hour	100 msec	2
28	displaying revolving warning light	ON/OFF	few bytes (a few contact points)	once per 10 secs. ~ 1 min.	0.5~2.5 sec.	30

Display (Cont'd)

(3) Visualization for monitoring production status

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
29	managing operation activity	image	6K	Continuous	500 msec.	1
30	supporting workers	PLC	200	once per 10 secs. ~ 1 min.	500 msec.	5
31	supporting maintenance	image, audio	200	once per 100 msec.	500 msec.	1

Human Safety

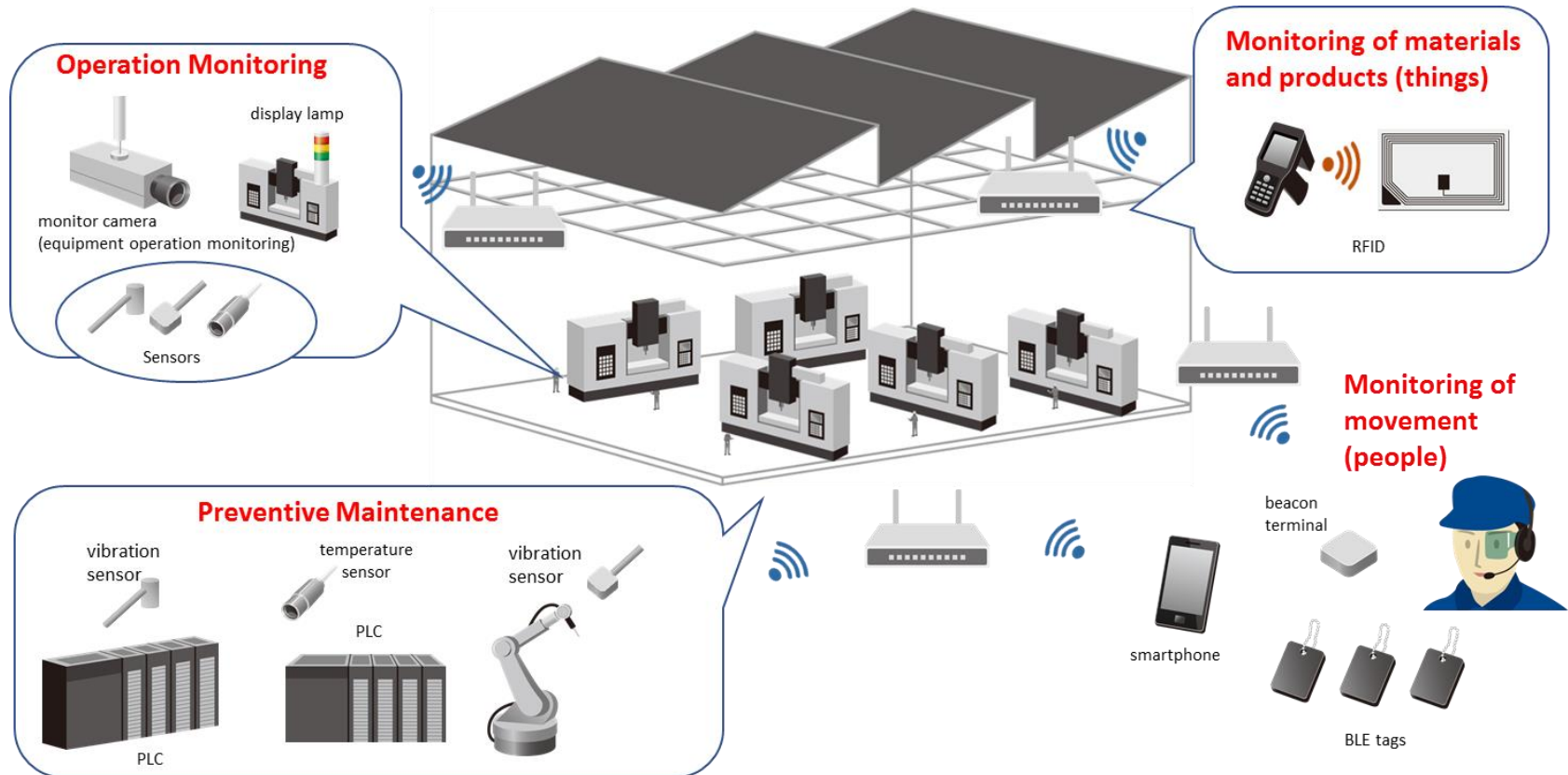
(1) Ensuring worker safety

No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
32	detecting dangerous operation	image	6K	10 per sec. (10fps)	1 sec.	1
33	Collecting bio info for managing worker safety	vitals information (mobile)	100	once per 10 sec.	1 sec.	9
34		vitals information (fixed)	200	once per 1 min.	5 sec.	20
35		gait	about 100K	1~10 per sec (1fps~10fps)	1 min.	10 to 20
36	detect entry to forbidden area	body temperature, infrared	2	when event occurs	1 sec.	1

Others

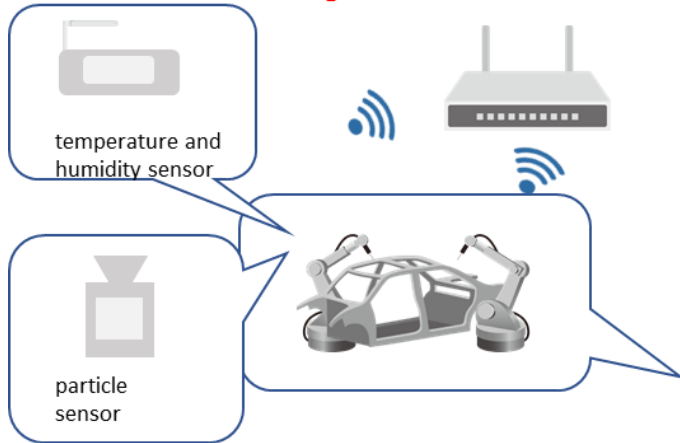
No.	Wireless application		Communication requirements			
	Purpose	Corresponding Information	Transmit Data Size (bytes)	Communication Rate	Delivery Time Tolerance	Node density (# of terminals per 20m x 20m)
37	sending data to robot teaching box	coordinates	few hundred kilobytes	twice per year	less than 500 msec. (safety standard)	10
38	relay of images moving	video	75K	30 per sec.		1
39	techniques, knowhow from experts	video, torque waveforms	24K	60 per sec. (60fps)	None	1

Usage scenarios example: Metal processing site

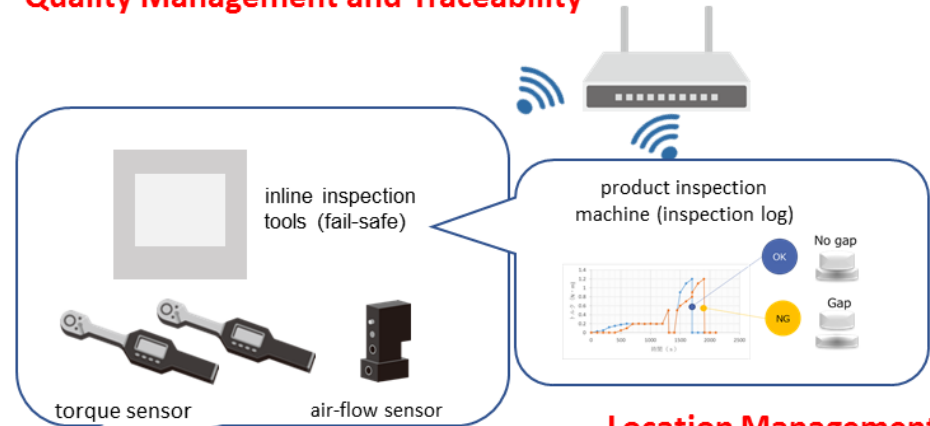


Usage scenarios example: Mechanical assembly site

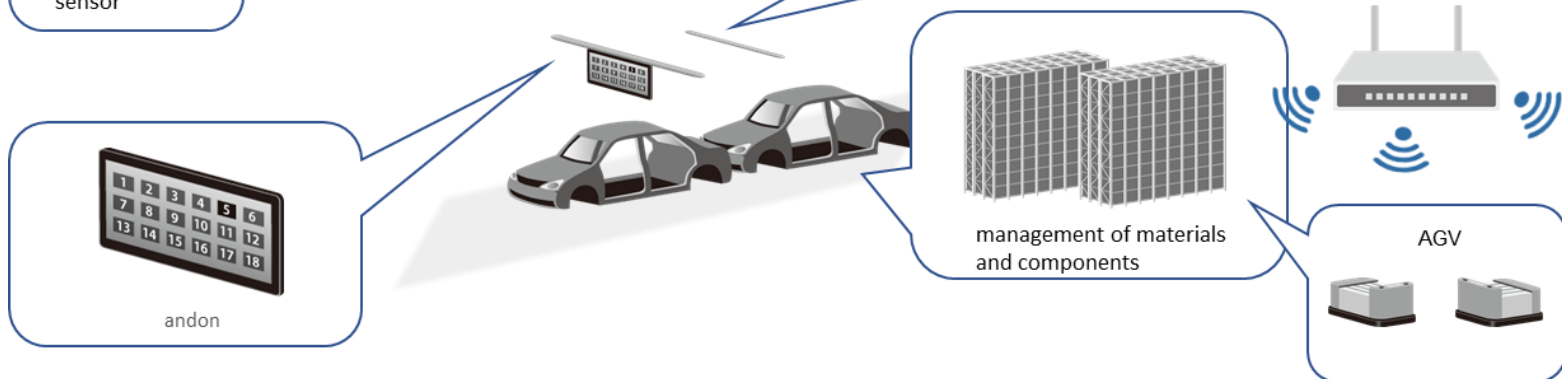
Welding and Painting Environment Management



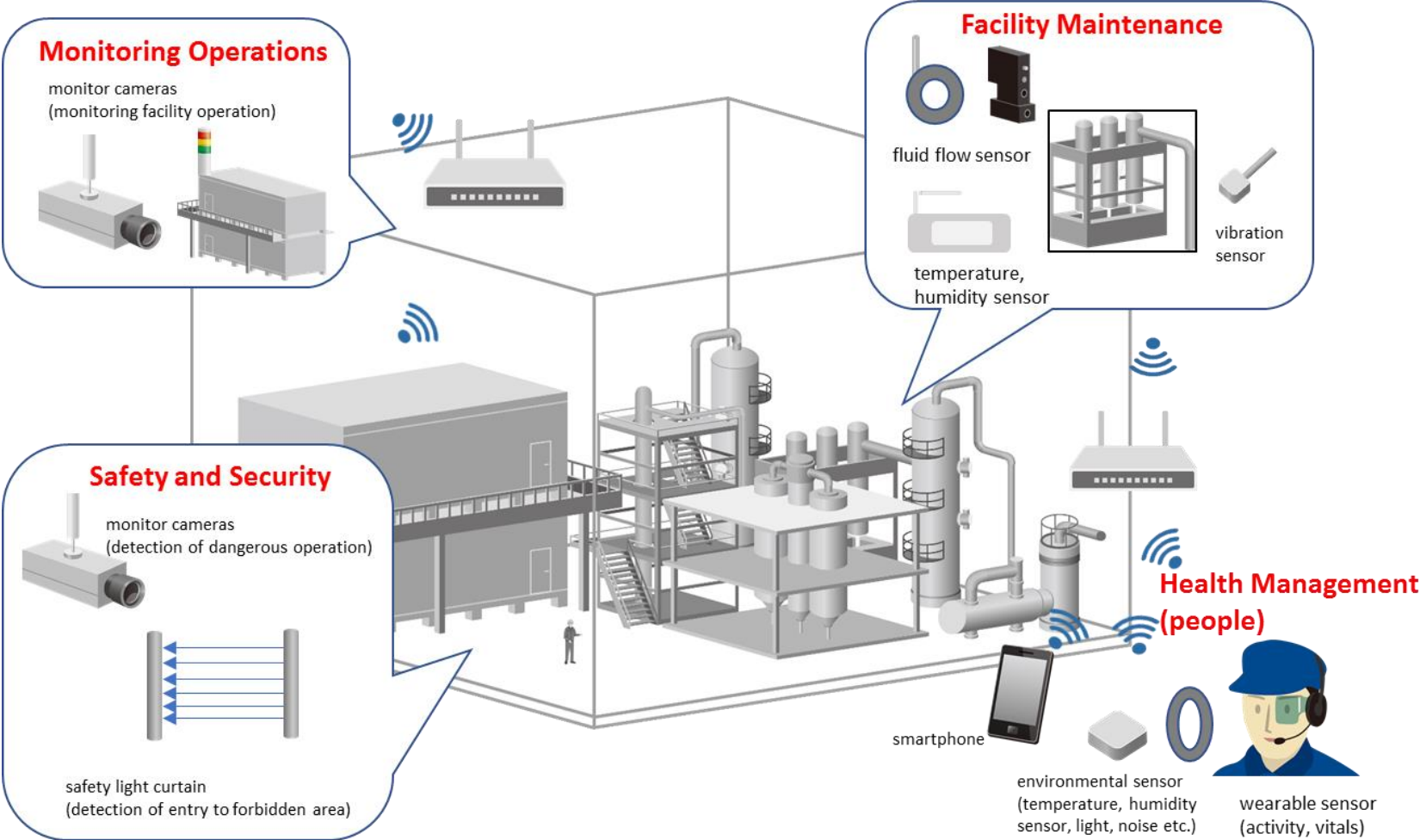
Quality Management and Traceability



Location Management

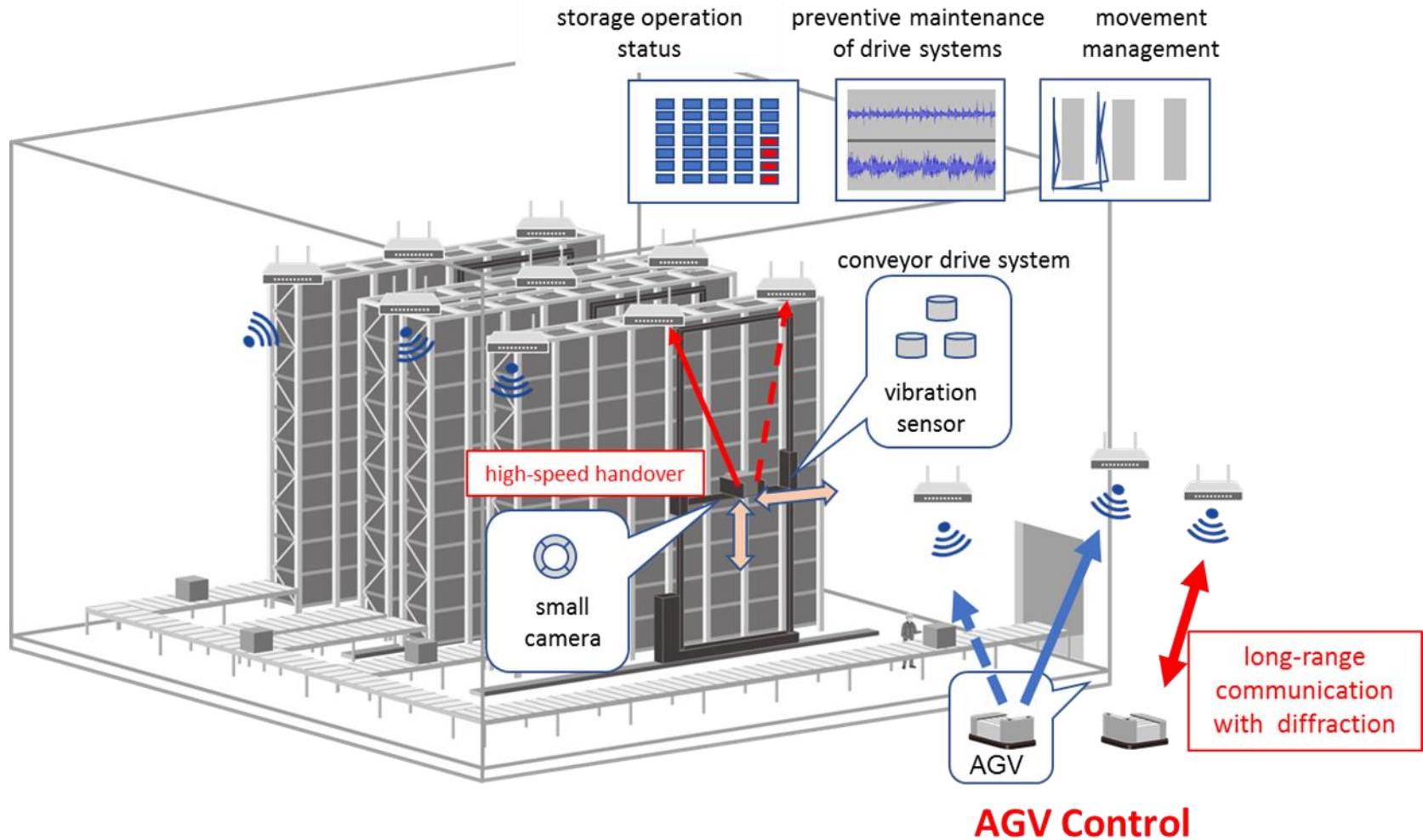


Usage scenarios example: Elevated and high temperature work site



Usage scenarios example: Logistics warehouse site

Equipment Maintenance (within automatic storage rack)



Summary

- The applications and communication requirements used currently or to be used in the factories were introduced.
- Four usage scenarios were presented.
- These are the candidates to be included in the report of Flexible Factory IoT for NEND.