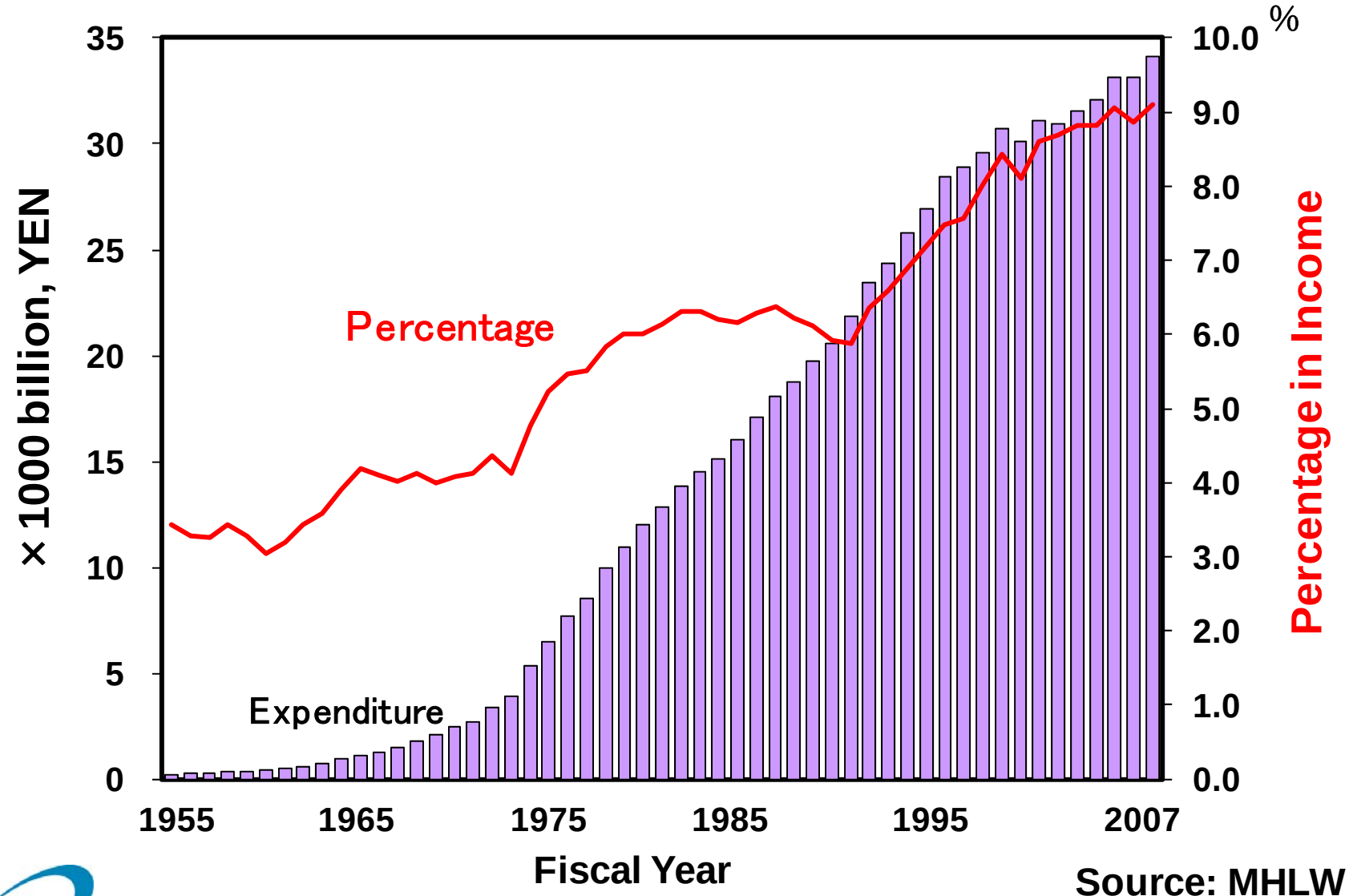
Prototype BANs for Health Monitoring and Visually Impaired People

Huan-Bang LI

Dependable Wireless Laboratory

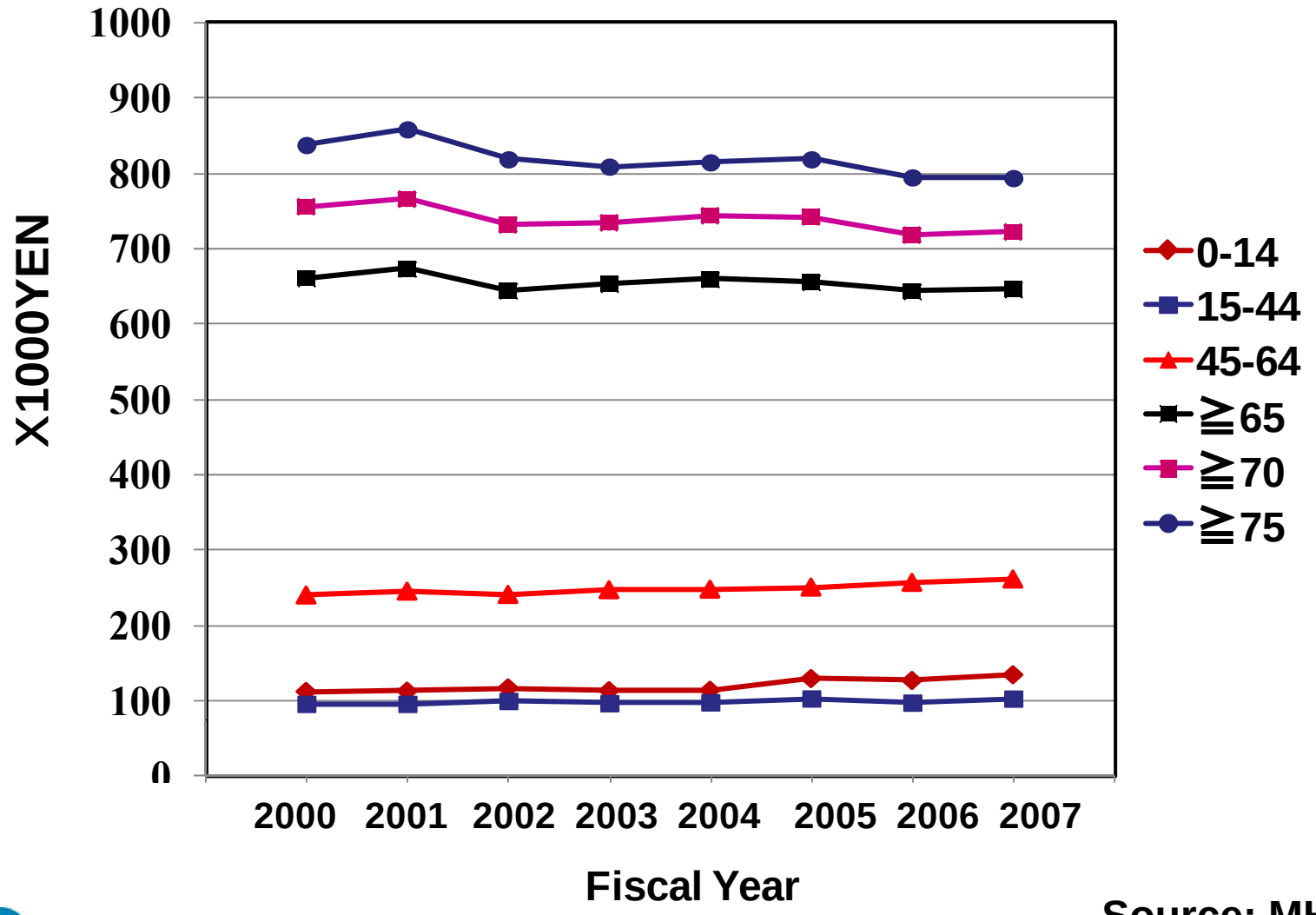
National Institute of Information and Communications Technology (NICT)

Medical Expenditure Per Year in Japan



Source: MHLW

Expenditure Per Person Sorted in Ages



Source: MHLW

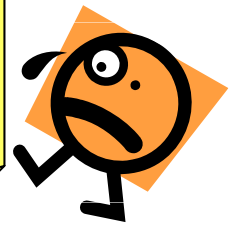
Observation

- Total medical expenditure increases year by year for decades.
- Expenditure per person per year doesn't increase obviously in past ten years.
- Elder generation spends more on medical than young generation

- The percentage of aging population is increasing.
- The population needs medical cares is increasing.

Needs For Medical BAN

In 2002, the major chronic diseases accounted for 43% of the global burden of disease and will reach 60% by 2020.

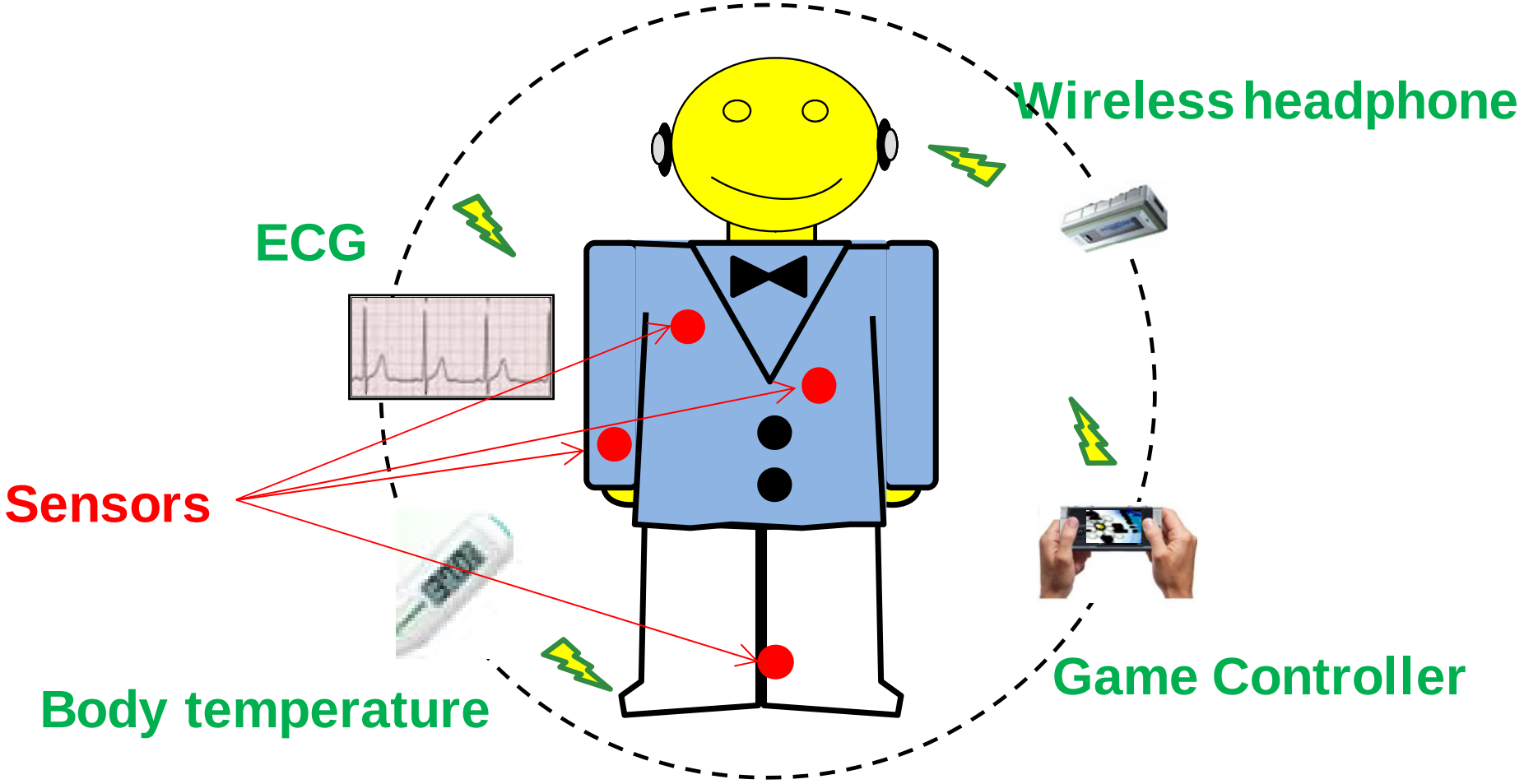


people 60 years of age and older is 650 million in 2007. By 2050, the "greying" population is predicted to reach 2 billion.

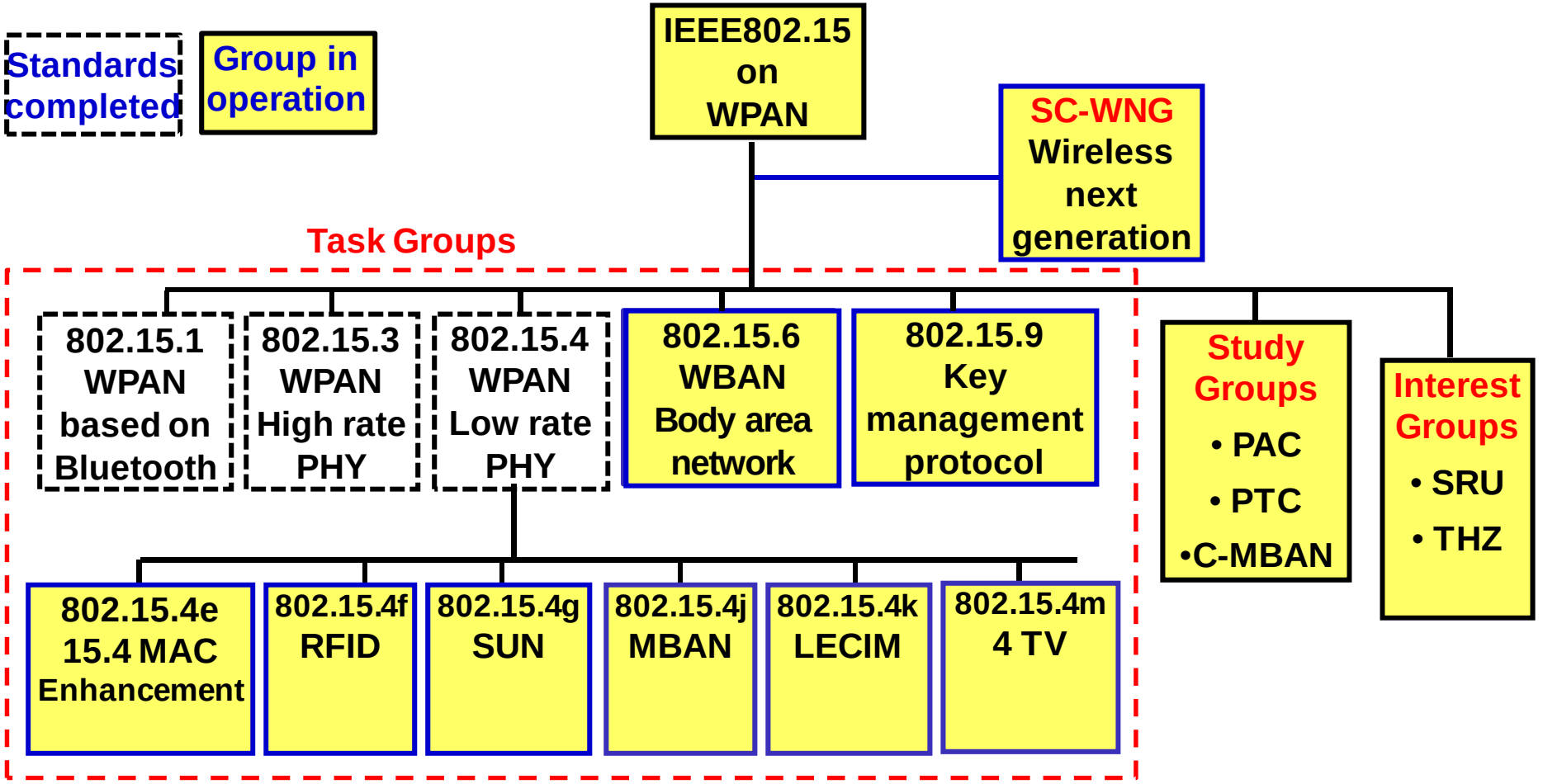
- **Prevention costs less than treatment does.**
- **Automatic vital signal collection and monitoring is point.**

Medical BAN

Definition of Body Area Network



Organization of 802.15



By November 2011

NICT's Main Works on BAN

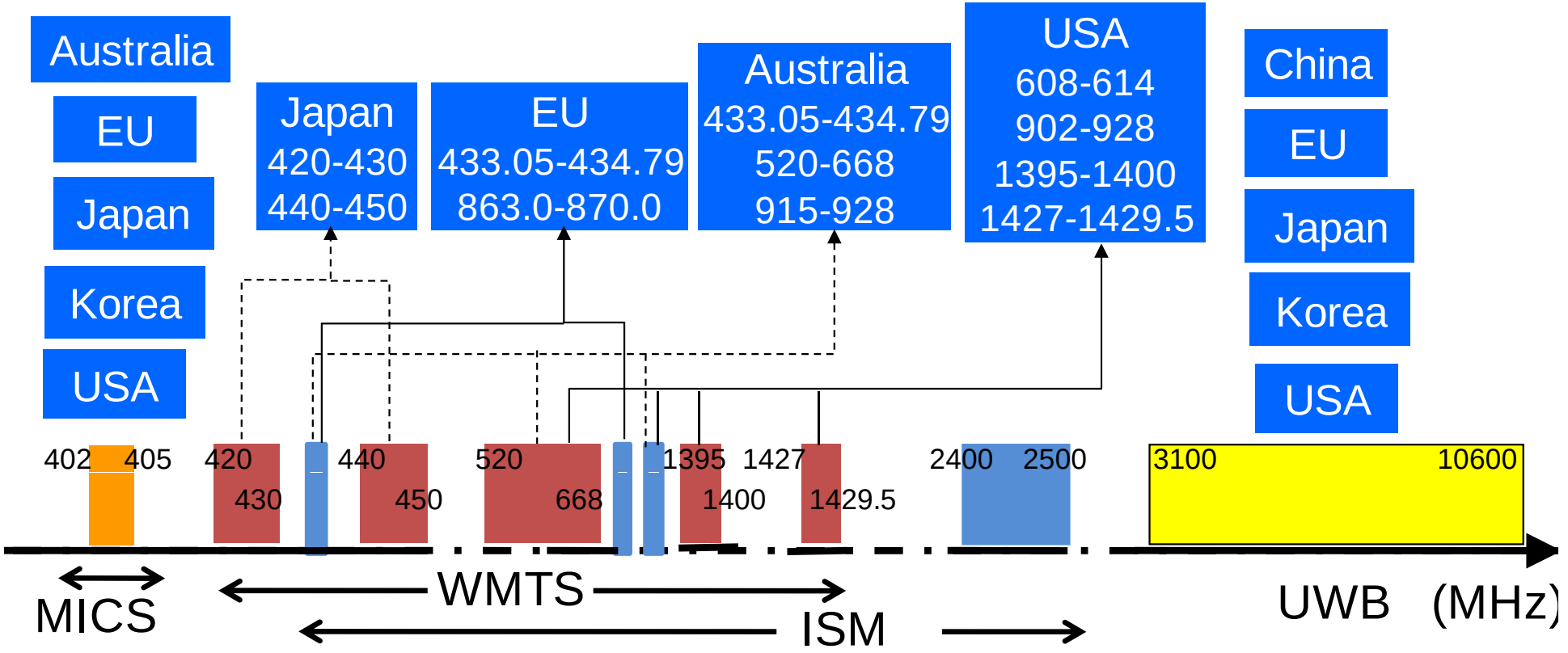
- **BAN Standardization**
  - ✓ **To have a successful commercialization, an international standard is a key.**
  - ✓ **NICT has been making a lot of major contributions for the standardization of IEEE 802.15.6.**
- **R & D for BAN Technology**
  - ✓ **A good technology is necessary to provide high quality medical and healthcare services.**
  - ✓ **NICT is developing BAN using both narrow band and UWB technologies.**

Main Contributors at TG6

- Casuh
- CEA-LETI
- CNU
- CSEM
- CUNY
- ETRI
- France Telecom
- Fujitsu Lab Europe
- Fujitsu ltd.
- GE Global Research
- GE Healthcare
- IMEC
- Inha University
- KETI
- Korpa
- LG Electronics
- Meiji Univesity
- *Mitsubishi Electric Research Labs, USA*
- NICT
- NICTA
- NIST
- Olympus, USA
- Philips, USA
- Philips, EU
- Samsung
- Tensorcom
- Texas Instrument
- Thales
- Toumaz Technologies
- Yokohama National University
- Zarlink Semiconductor
- … …

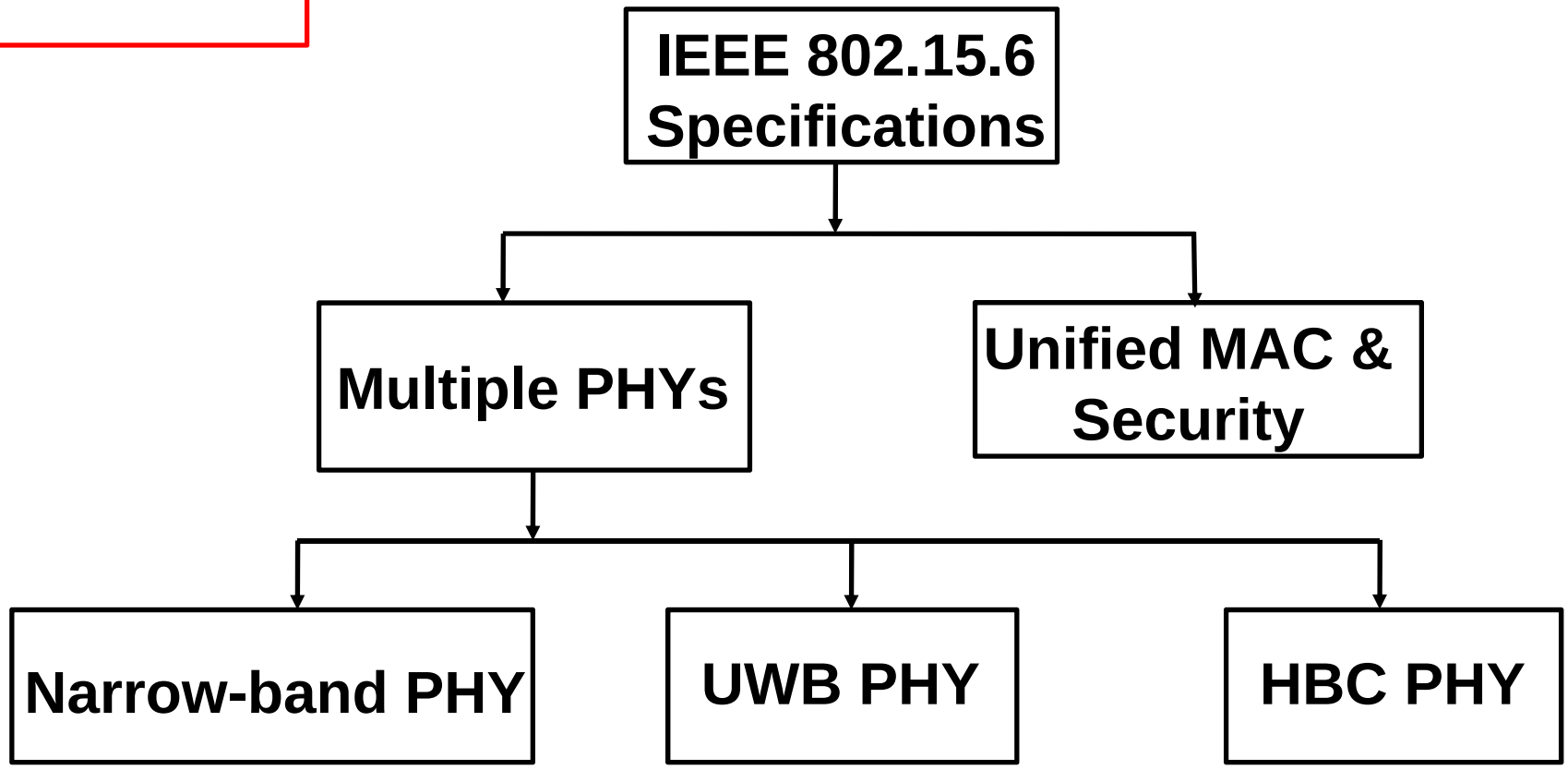
Asia
Europe
USA

Frequency Band Candidates



Structure of IEEE 802.15.6

Draft 06



Three Channel Access Modes

Channel access mode	Time reference-based (superframe structure)	Beacon	Notes
I	Yes	Yes	Coordinator sends beacon in each superframe except for inactive superframes.
II	Yes	No	Coordinator establishes time reference but doesn't send beacon.
III	No	No	There is not time reference.

Priority Definition

Priority level	Traffic designation	Data type
7	Emergency or medical event report	Data
6	High priority medical data or network control	Data or management
5	Medical data or network control	Data or management
4	Voice	Data
3	Video	Data
2	Excellent effort	Data
1	Best effort	Data
0	Background	Data

Main Specifications of NB-PHY

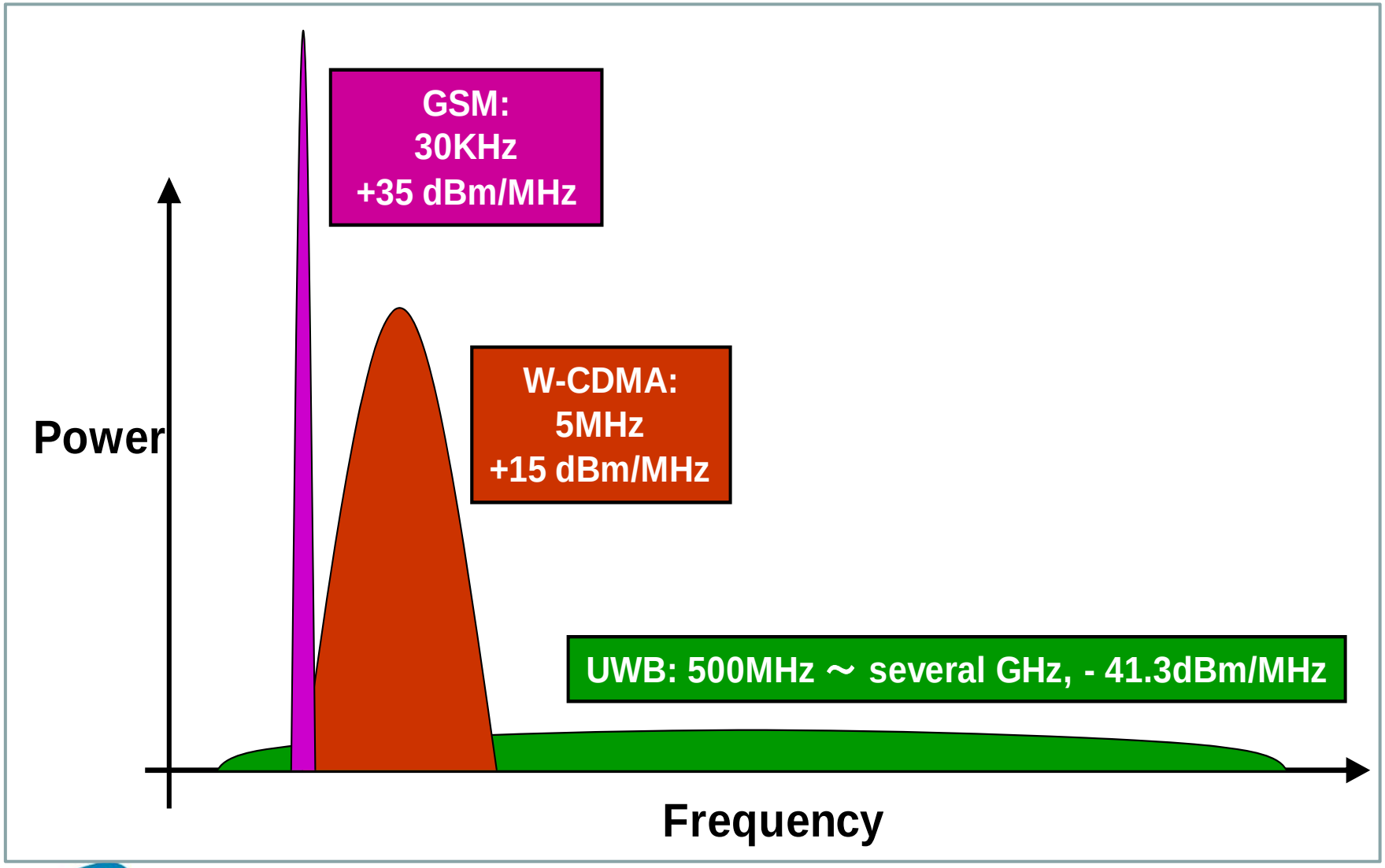
Frequency bands (MHz)	Modulations		Data rates (kbps)	Number of channel	Notes
	PLCP header	PSDU			
402-405	π/2-DBPSK	π/2-DBPSK, π/4-DQPSK π/8-D8PSK	75.9/151.8/ 303.6/455.4	10	Majority of countries
420-450	GMSK	GMSK	75.9/151.8/187.5	12	Japan
863-870	π/2-DBPSK	π/2-DBPSK, π/4-DQPSK π/8-D8PSK	101.2/202.4/ 404.8/607.1	14	EU
902-928	π/2-DBPSK	π/2-DBPSK, π/4-DQPSK π/8-D8PSK	101.2/202.4/ 404.8/607.1	60	North America, Australia
950-958	π/2-DBPSK	π/2-DBPSK, π/4-DQPSK π/8-D8PSK	101.2/202.4/ 404.8/607.1	16	Japan
2360-2400	π/2-DBPSK	π/2-DBPSK, π/4-DQPSK	121.4/242.9/ 485.7/971.4	39	USA
2400-2483.5	π/2-DBPSK	π/2-DBPSK, π/4-DQPSK	121.4/242.9/ 485.7/971.4	79	Worldwide

Main Specifications of UWB-PHY

Mode	Modulation	Data rate (Mbps)	Waveform
IR-UWB (I)	OOK	0.49 – 15.6	Chirp pulse, chaotic pulse, SRRC-like pulse, or others.
IR-UWB (II)	DBPSK/DQPSK	0.49 – 15.6	
FM-UWB	Continuous-phase 2FSK (sub carrier) combined with FM	≦0.25	Gaussian (default)

- FM-UWB is an optional mode
- High QoS mode
  - Hybrid Type II ARQ

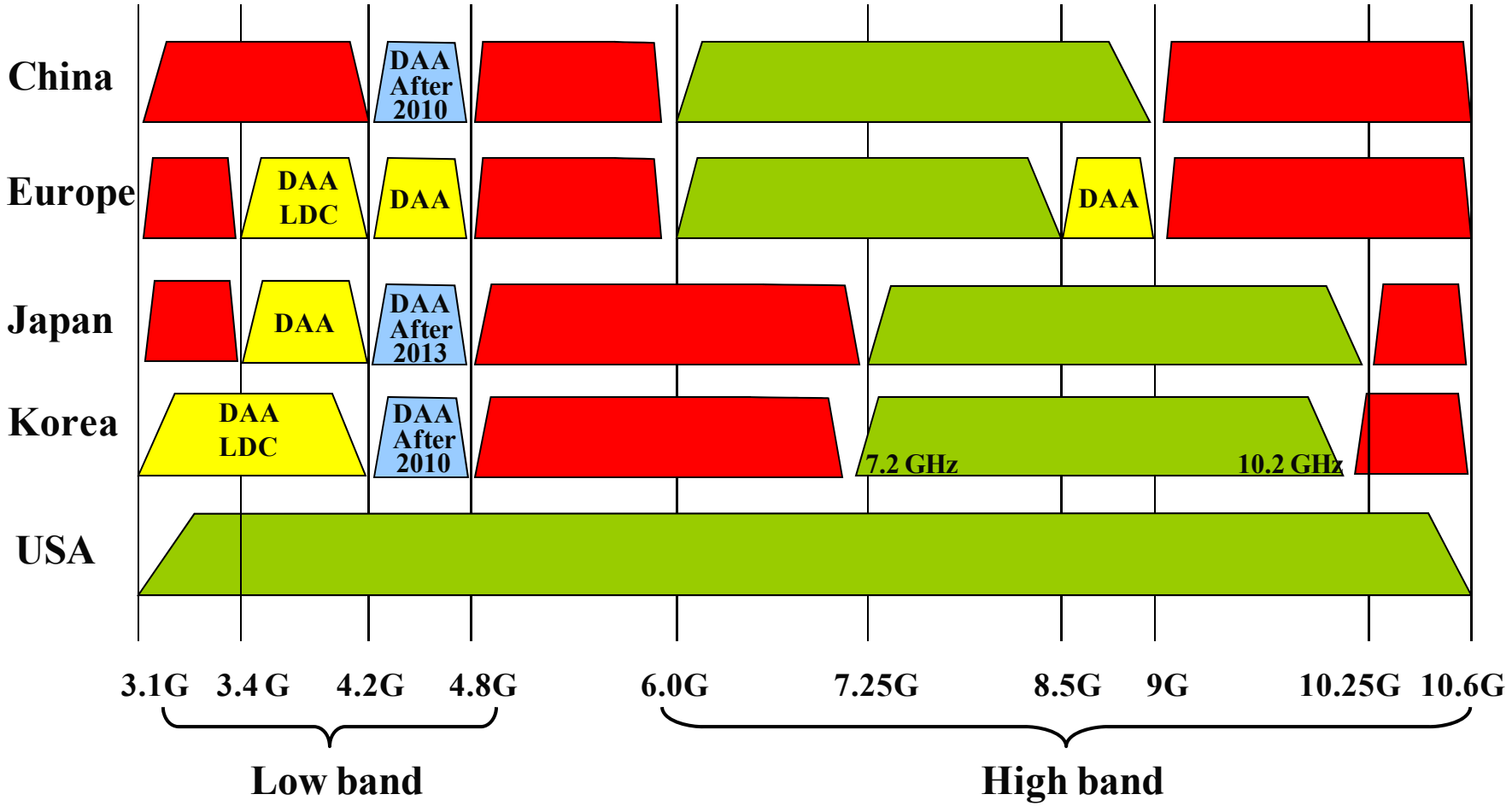
Definition Of UWB



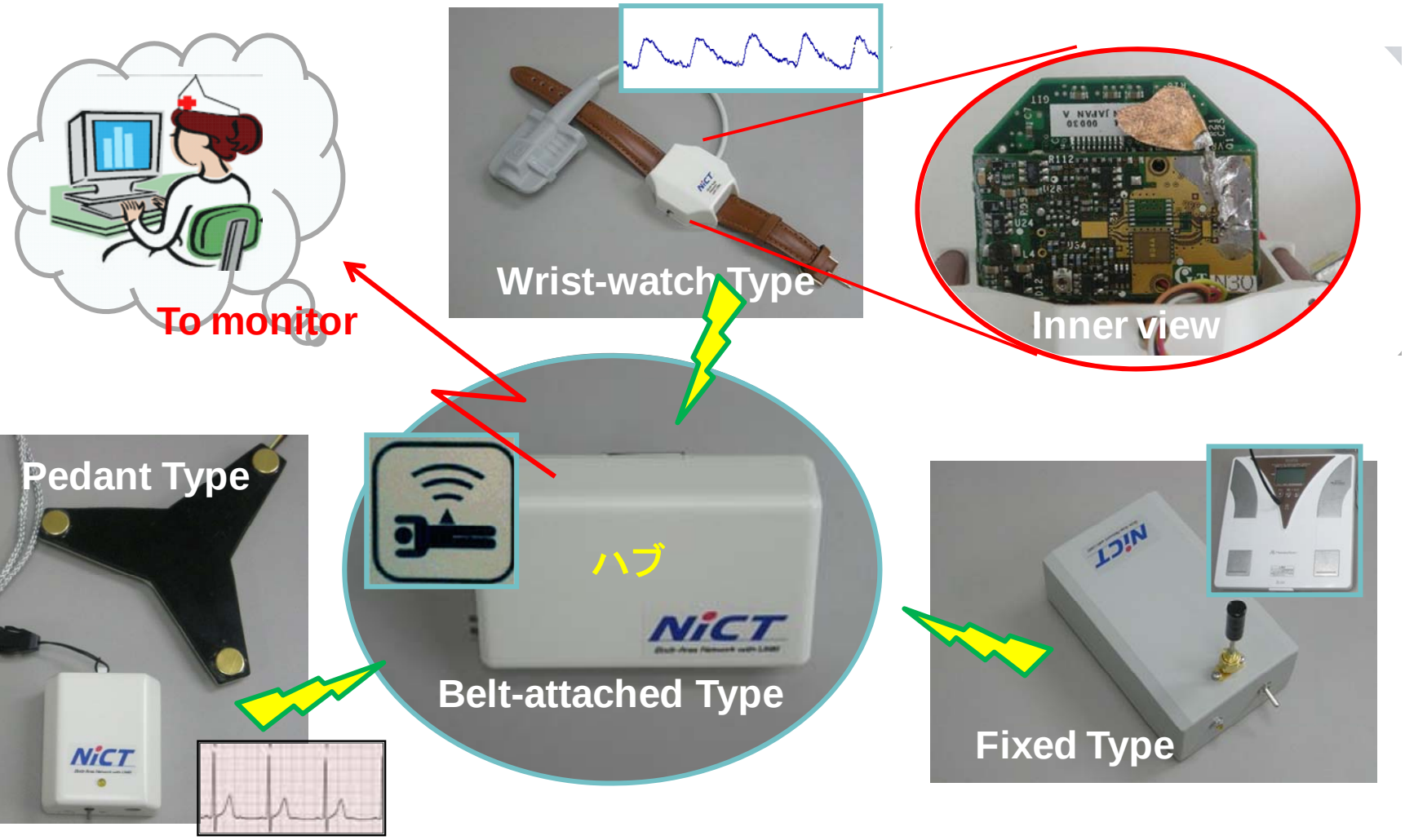
The Advantages of Using UWB

- **UWB is inherently low power consumption. That is favorable for BAN device to operate on small battery for a long period.**
- **Because of the extremely low emission power density, the effect to human body and organ is very low.**
- **Because of the extremely low emission power density as well as the high frequency, the transmission distance is limited and good for co-existence.**
- **UWB can provide high precision ranging, that is desired in some applications.**

World Wide UWB Regulations



Prototype BAN Using UWB Highband

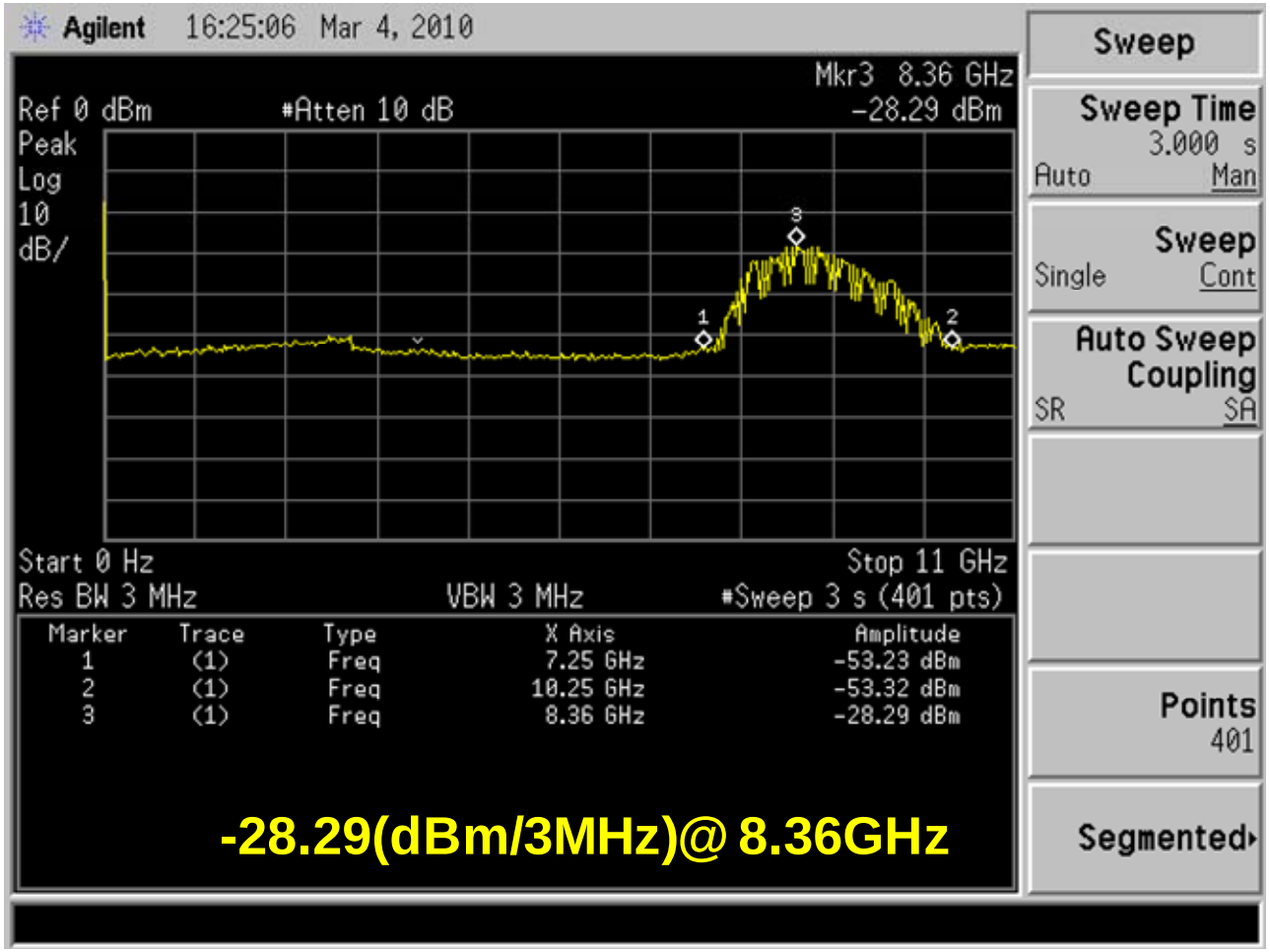


Prototype BAN Using UWB Highband

Specifications of High Band UWB

Items	Specifications
Frequency band	7.25 – 10.25 GHz
Average e.i.r.p.	≤ -41.3 dBm/MHz
Peak e.i.r.p.	≤ 0 dBm/50MHz
Average unwanted radiation	≤ -70 dBm/MHz
Peak unwanted radiation	≤ -64 dBm/MHz
Pulse rate	~ 50 Mpps
Communication range	~ 3m

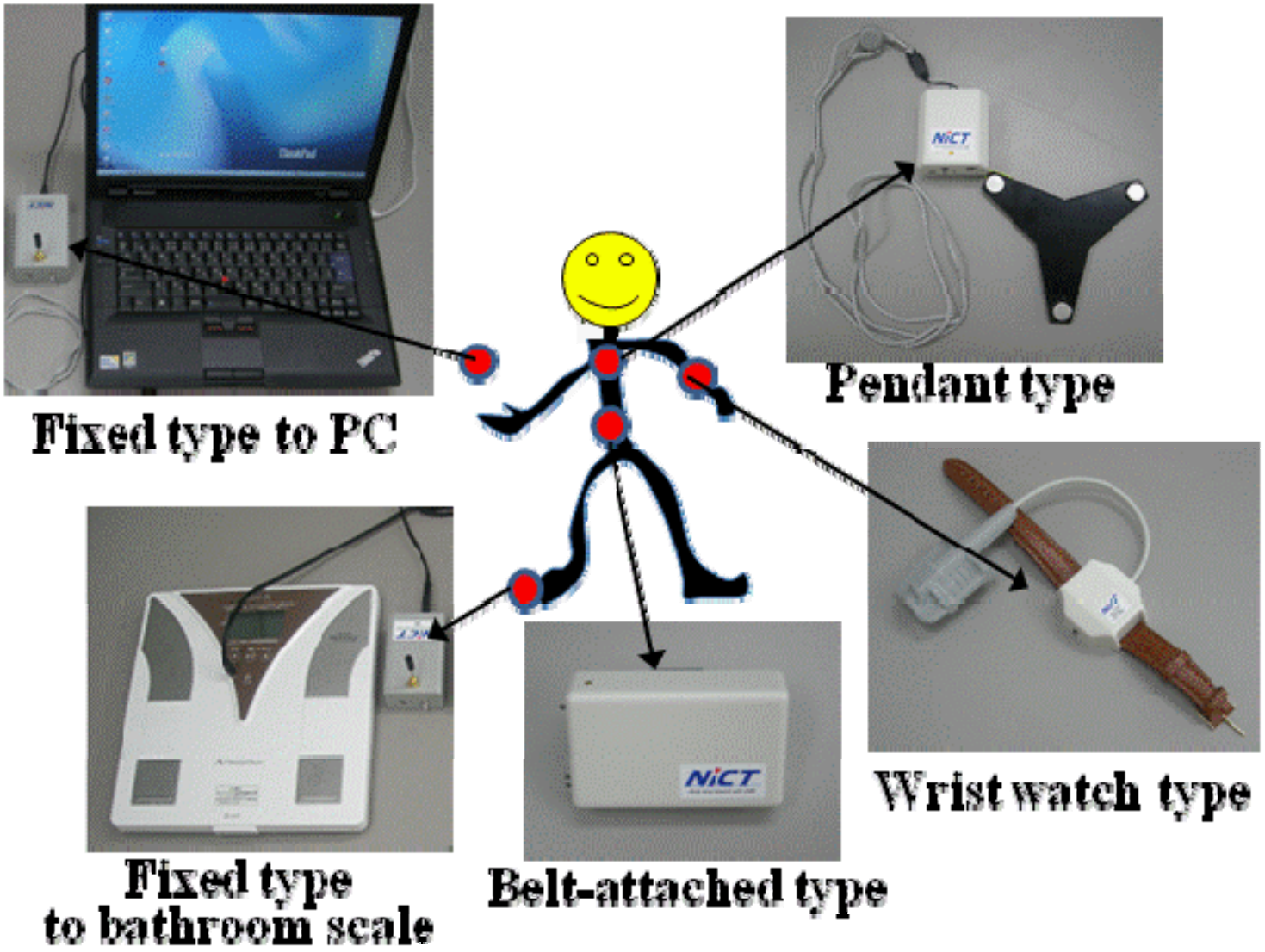
Peak Power of UWB Signal



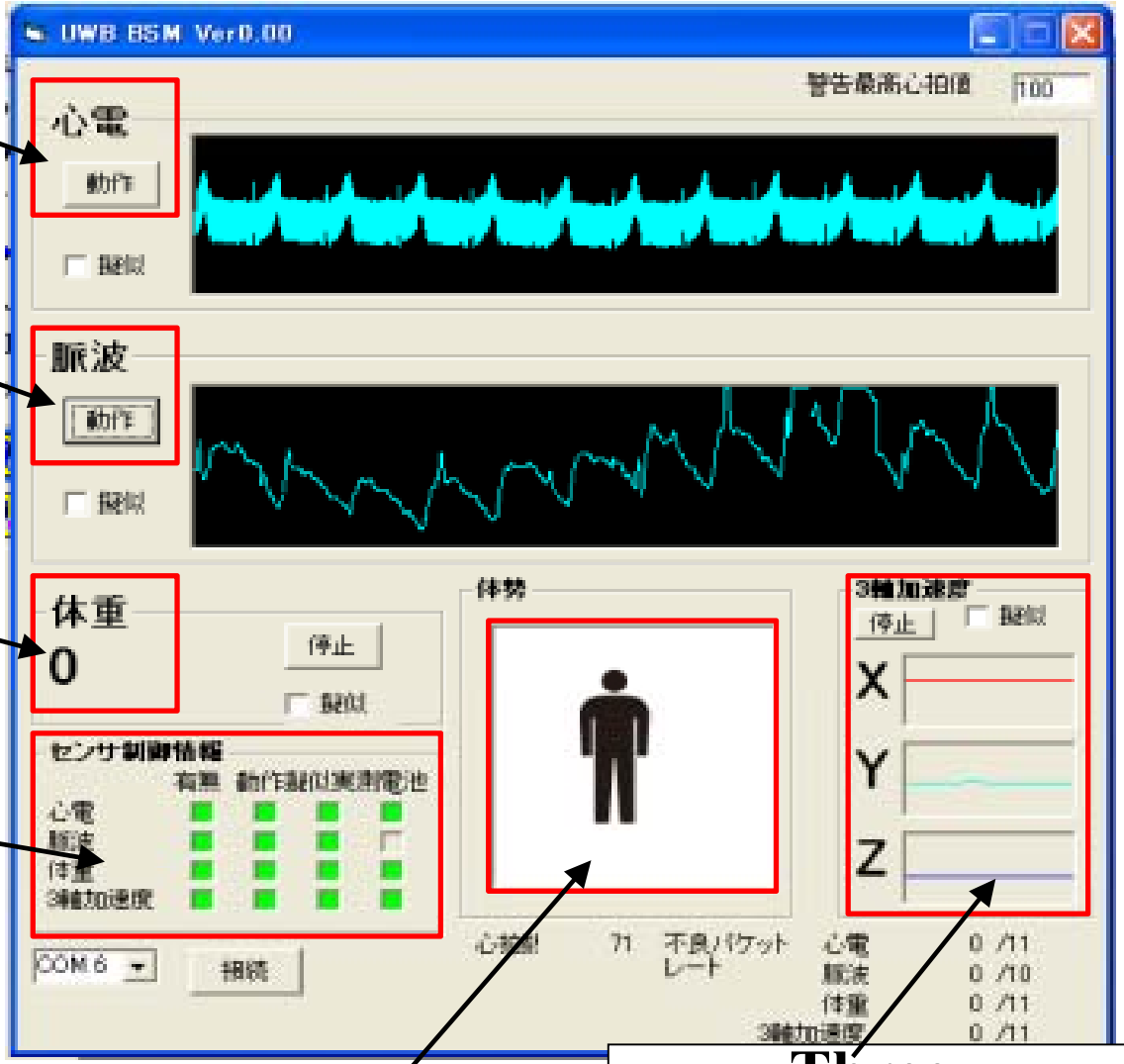
Calculation of Peak Power:

$$P_{peak} = -28.29\text{dBm/3MHz} + 20\log\left(\frac{50\text{MHz}}{3\text{MHz}}\right) = -3.86\text{dBm/50MHz}$$

Overview of A High-band UWB BAN



Monitor of Various Data



ECG

Carotid Pulse

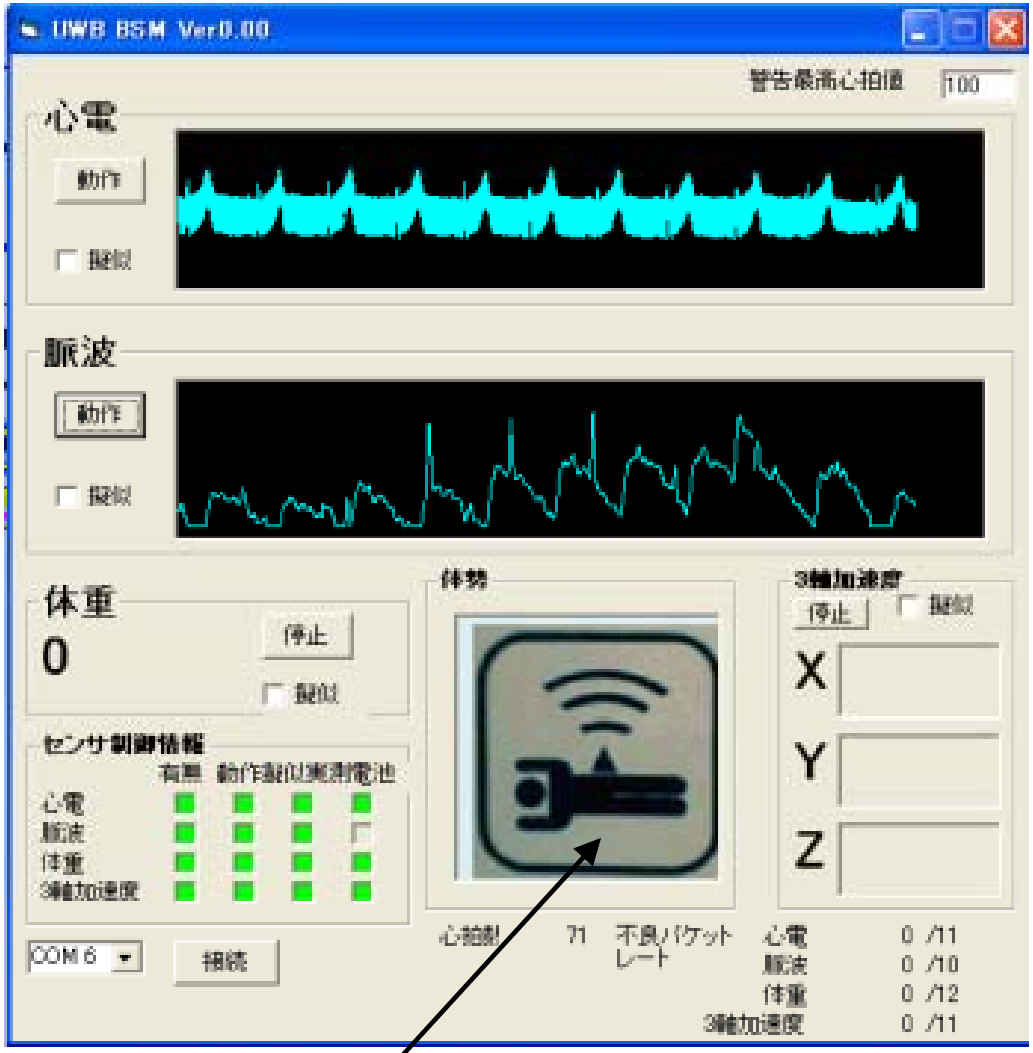
Weight

Device status

Attitude

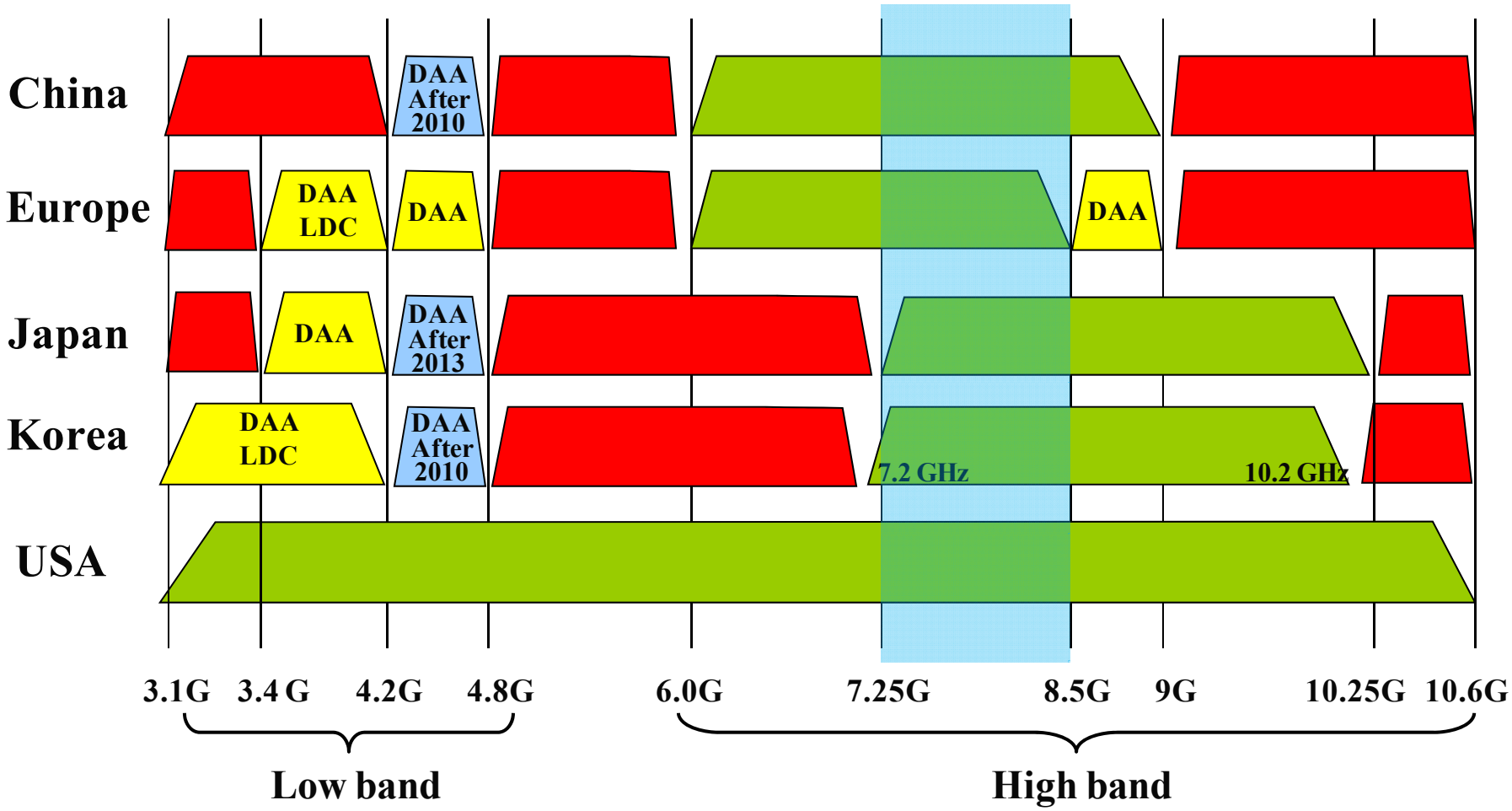
Three-dimensional Acceleration data

Alarm Functions



Fall-down alarm

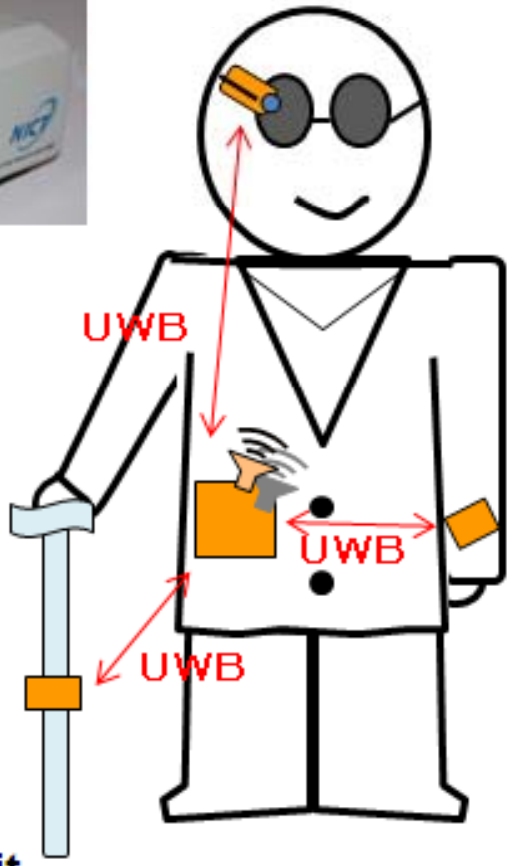
World Wide UWB Regulations



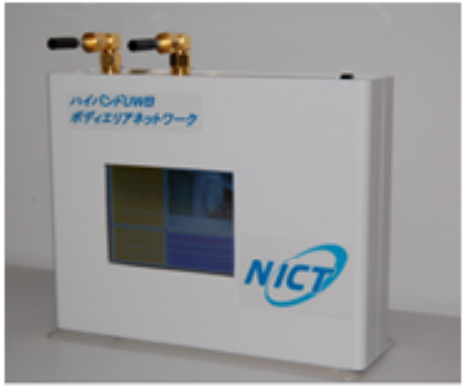
BAN For People With Visual Disability

Camera unit
(Taking video)

Wrist watch unit
(SpO2, pulse, temperature)

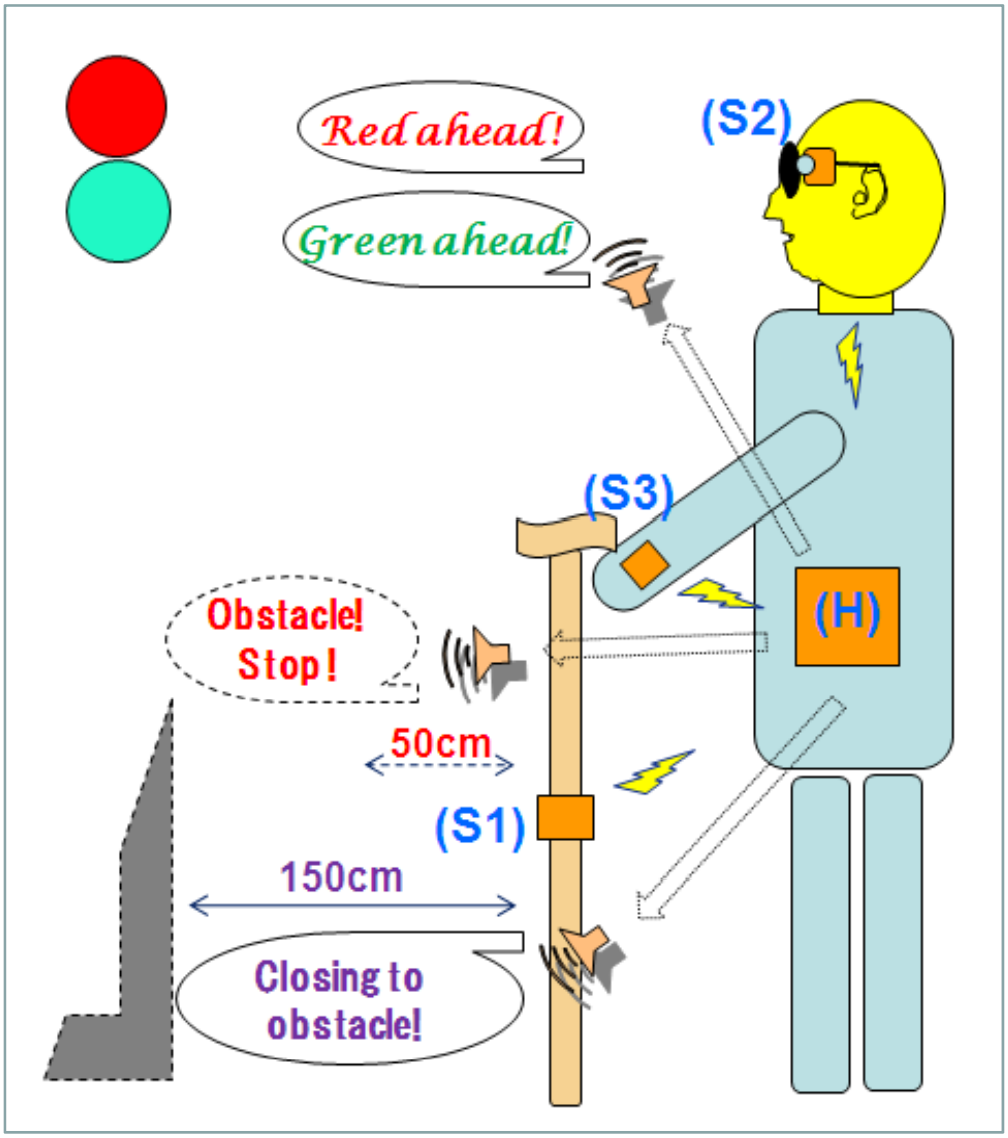


Stick-attached unit
(Ultrasonic sensor)



Belt-attached unit
(Processing and audio guide)

Usage Of The Developed BAN



Conclusion Remarks

- **Body area network (BAN) is considered as an important technology in supporting automatic medical monitoring and healthcare agilence services as well as consumer centric electronics.**
- **A new standard, IEEE 802.15.6 is expected to be published in 1Q of 2012, which defines the specifications of both PHY and MAC for BAN.**
- **UWB is a technology with low consumption power and low emission power level, that are favorable in implementing BAN.**
- **Two prototype BANs developed by NICT were introduced. More works need to do in order to provide better solutions.**

Introduction of NICT

The sole National Research Institute of ICT JAPAN

Major Research & Development