

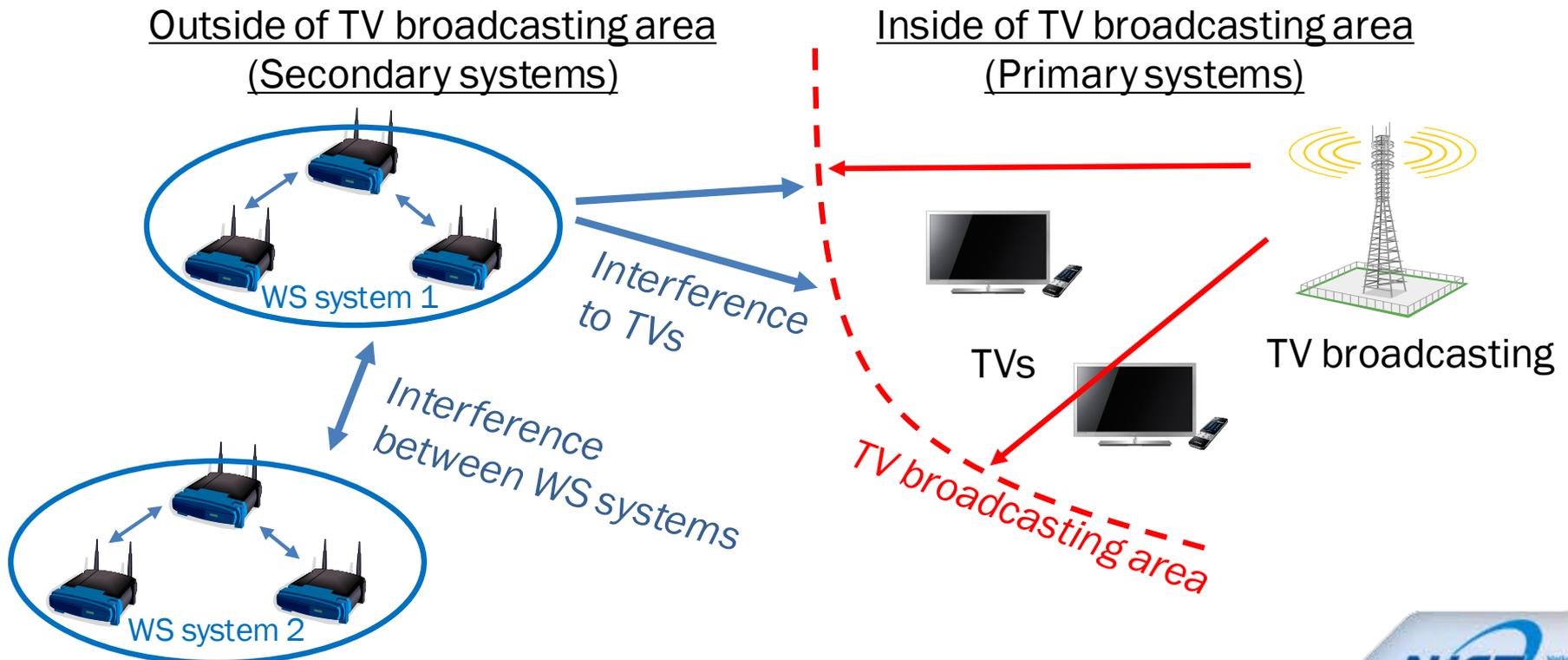
TV White Space Technologies and Social Deployments

Dr. Kentaro Ishizu

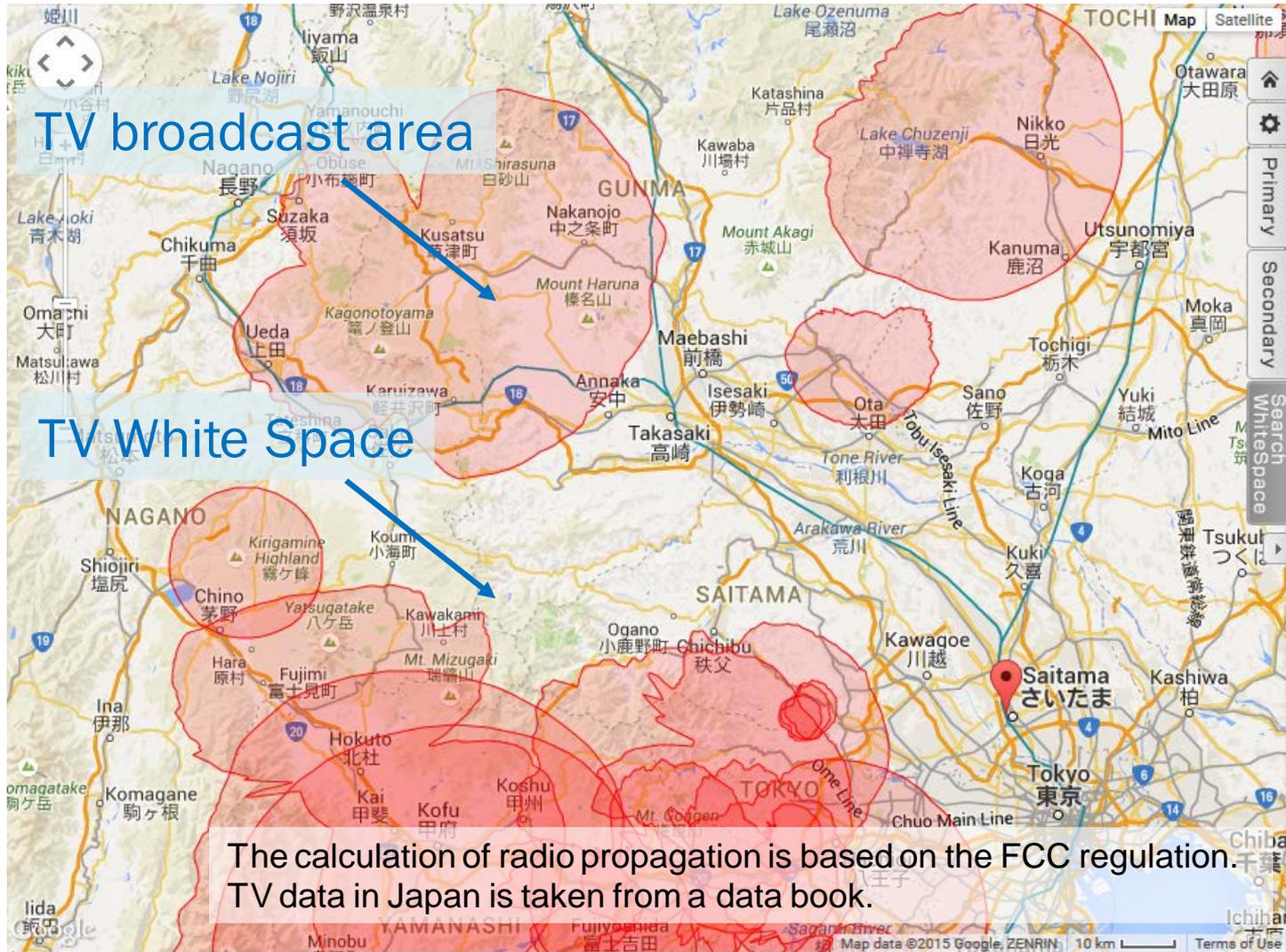
Research Manager,
Smart Wireless Laboratory, Wireless Network Research Institute,
National Institute of Information and Communications Technology (NICT)

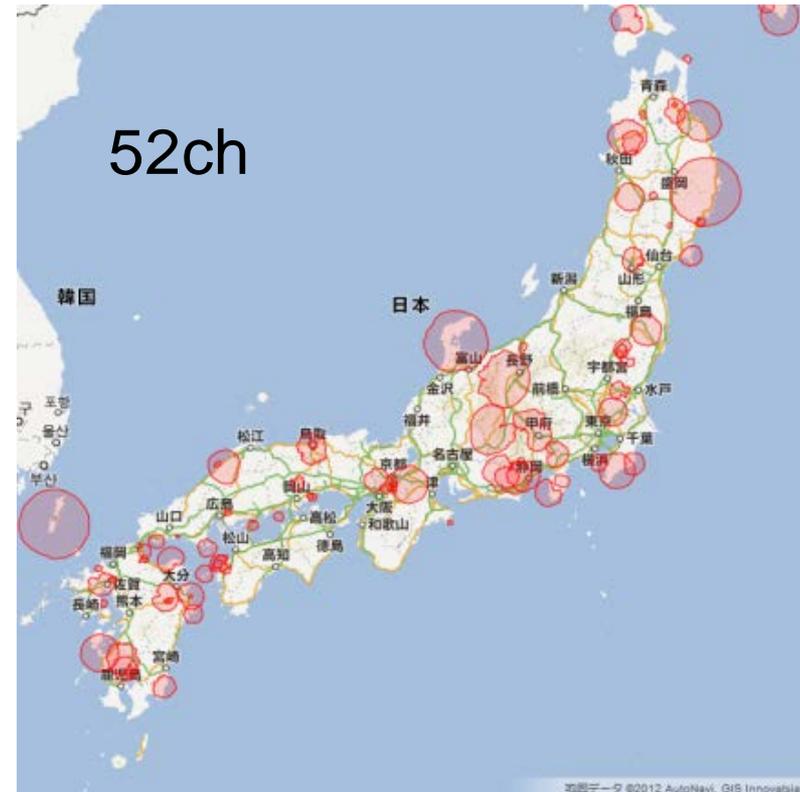
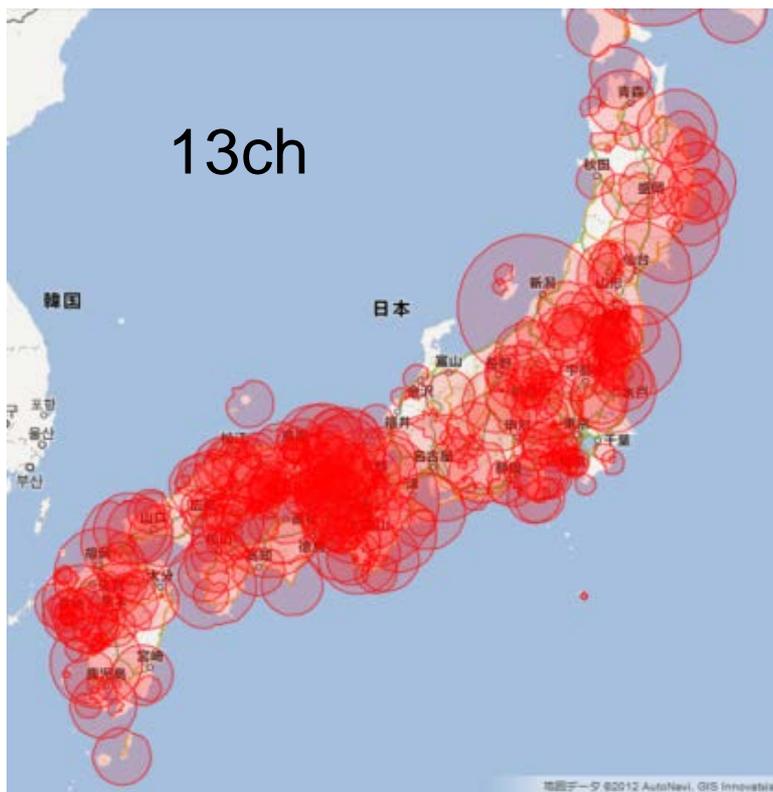
November 26, 2015 @ASEAN IVO Forum

- TV White Space (TVWS) is used without interference to primary systems (TV broadcasts).
- TVWS band have a good feature in radio propagation.
- TVWS is expected to improve the spectrum utilization efficiency.



Availability of TV White Space



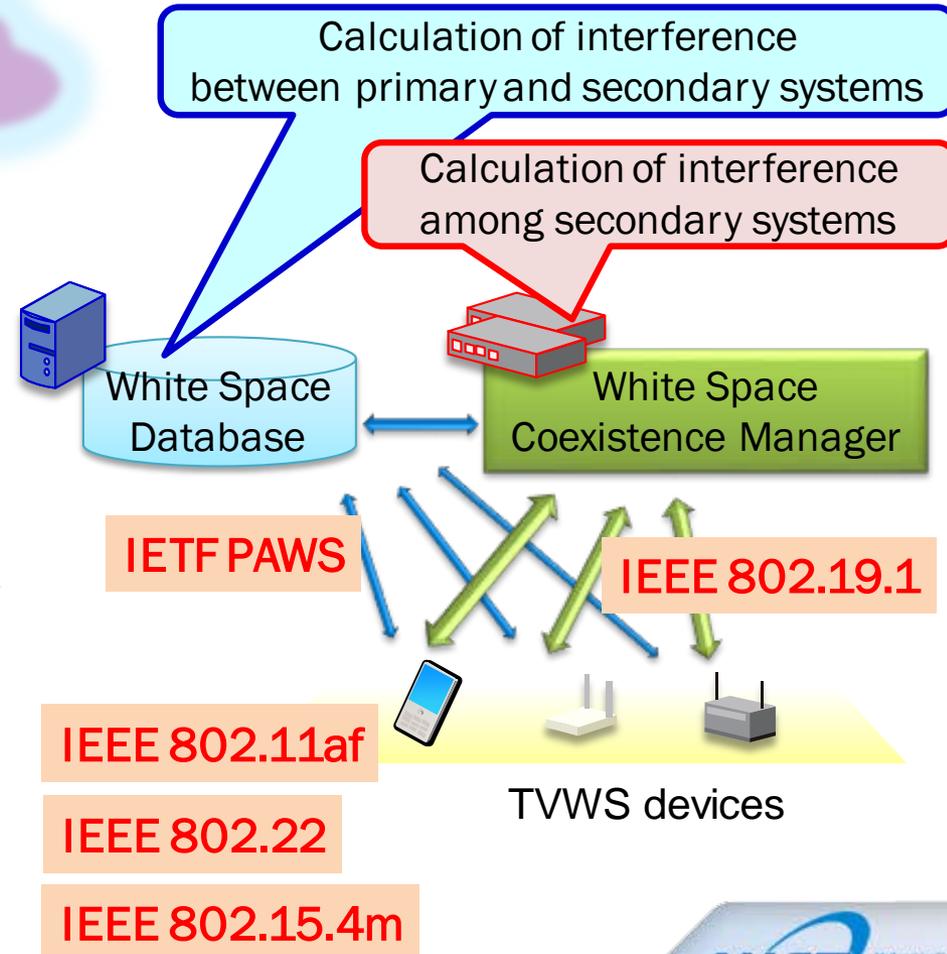
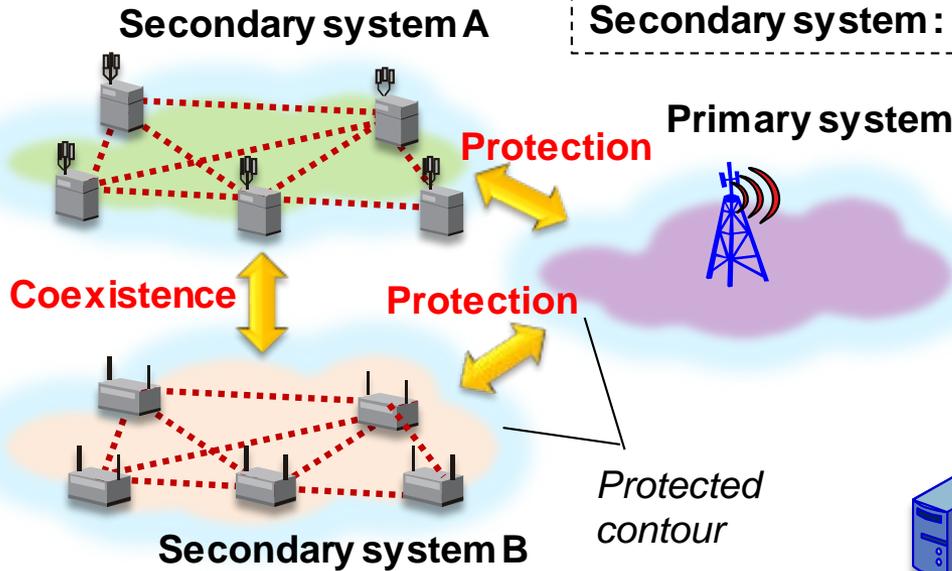


Availability of TVWS is different from location to location.
Occupancy of each channels is different.
Some technologies are required to find the TV White Space.

The calculation of radio propagation in the Figures is based on the FCC regulation. TV data in Japan is taken from a data book. The availability of TVWS above is just an example.

Necessity of Standardization

Primary system : TV broadcasts
Secondary system : TV White Space communications



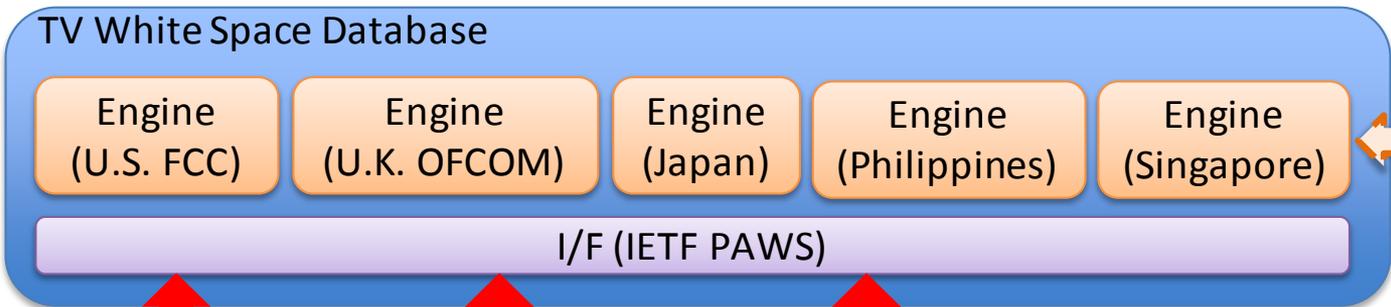
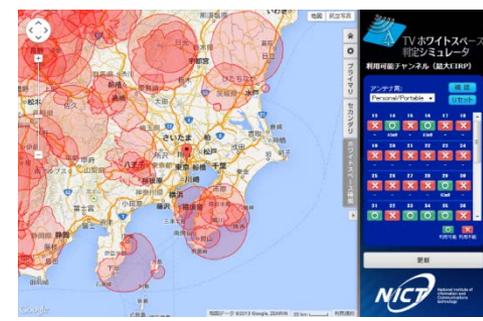
Standardization of technology

- Interoperability of products
- Scalability of utilization
- Expansion of business

Overview of TVWS technologies of NICT

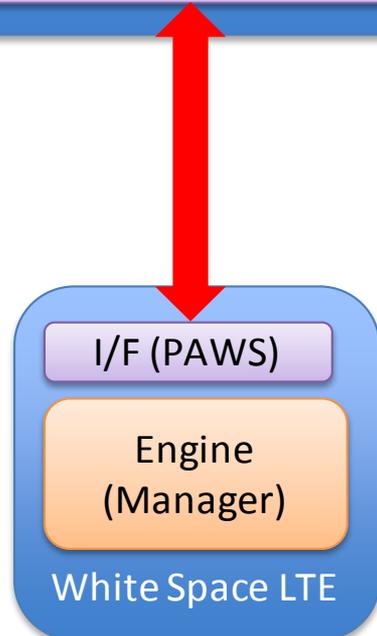
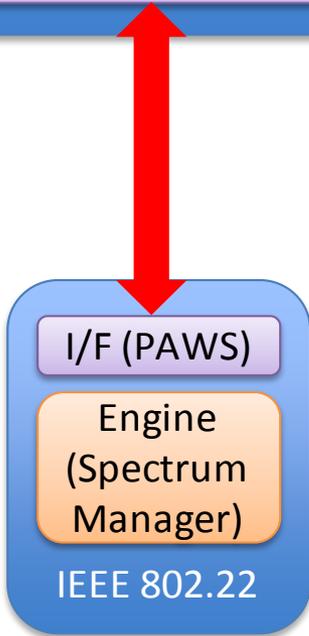
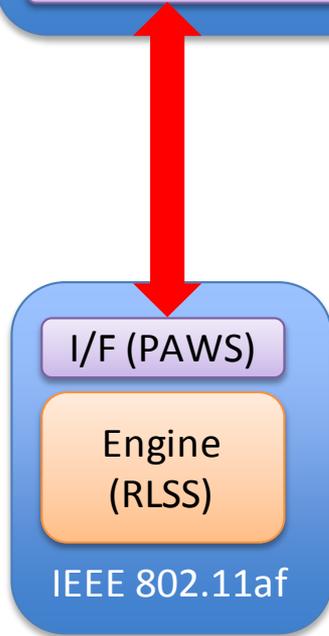
Qualified by Ofcom, U.K.

Adopted by Philippines



Plug-in

Engine (Others)



Spectrum mask satisfied (FCC, ETSI)

Available channel list
(CHs in green are TWWS)

A pin to specify a location
to check TVWS availability

| EIRP) | | | | | |
|-------------------|------|------|-----------|-------------|-------|
| Antenna height: | | | | | |
| Personal/Portable | | | | | |
| 13 | 14 | 15 | 16 | 17 | 18 |
| X | ✓ | X | ✓ | X | ✓ |
| - | 40mW | - | 100mW | - | 100mW |
| 19 | 20 | 21 | 22 | 23 | 24 |
| ✓ | X | X | X | X | X |
| 40mW | - | - | - | - | - |
| 25 | 26 | 27 | 28 | 29 | 30 |
| X | X | X | X | ✓ | ✓ |
| 40mW | - | - | - | 40mW | 100mW |
| 31 | 32 | 33 | 34 | 35 | 36 |
| ✓ | X | ✓ | ✓ | ✓ | X |
| 40mW | - | 40mW | 100mW | 100mW | - |
| 37 | 38 | 39 | 40 | 41 | 42 |
| | | | ✓ | X | |
| | | | available | unavailable | |

Refresh

NICT National Institute of Information and Communications Technology

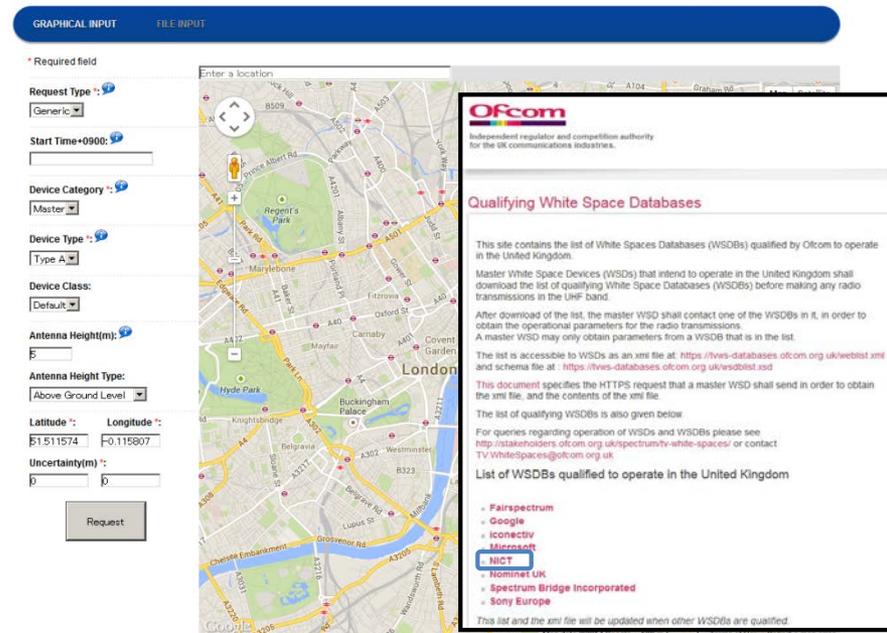
- WSDB calculates interference of secondary systems to primary systems according to radio propagation models based on geography.
- Then, availability of TV channels are determined based on interference level at each location.

- Qualified by U.K. Ofcom for its TVWS Pilot project.
 - ▶ Real time management to protect higher priority systems, i.e. radio mic operations in TVWS

- Adopted by ICTO of Philippines for its Free Wi-Fi Project.
 - ▶ Press release on May 7, 2015

- Licensed by Singapore IDA for experimental TVWS operation.

OFCOM OPERATIONAL PARAMETERS INFORMATION SYSTEM



Graphical Input | FILE INPUT

* Required field

Request Type: Generic

Start Time: 0900

Device Category: Master

Device Type: Type A

Device Class: Default

Antenna Height(m):

Antenna Height Type: Above Ground Level

Latitude: 51.511574 Longitude: -0.115807

Uncertainty(m): 0

Request

Ofcom
Independent regulator and competition authority for the UK communications industries.

Qualifying White Space Databases

This site contains the list of White Spaces Databases (WSDBs) qualified by Ofcom to operate in the United Kingdom.

Master White Space Devices (WSDs) that intend to operate in the United Kingdom shall download the list of qualifying White Space Databases (WSDBs) before making any radio transmissions in the UHF band.

After download of the list, the master WSD shall contact one of the WSDs in it, in order to obtain the operational parameters for the radio transmissions.

A master WSD may only obtain parameters from a WSD that is in the list.

The list is accessible to WSDs as an xml file at: <https://tvws-databases.ofcom.gov.uk/wsdlist.xml> and schema file at: <https://tvws-databases.ofcom.gov.uk/wsdlist.xsd>

This document specifies the HTTPS request that a master WSD shall send in order to obtain the xml file, and the contents of the xml file.

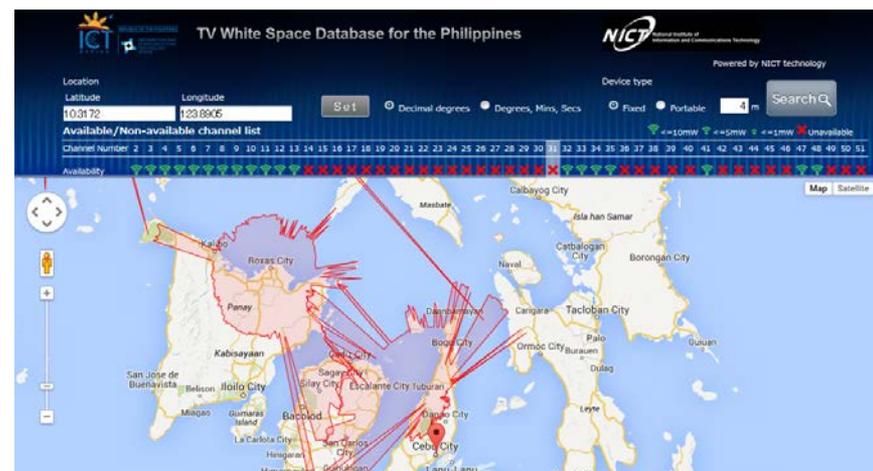
The list of qualifying WSDBs is also given below:

For queries regarding operation of WSDs and WSDs please see <http://stakeholders.ofcom.gov.uk/consult/condocs/white-spaces/> or contact TV.WhiteSpaces@ofcom.gov.uk

List of WSDBs qualified to operate in the United Kingdom

- FairSpectrum
- Google
- Iconectiv
- Microsoft
- **NICT**
- Nomnet UK
- Spectrum Bridge Incorporated
- Sony Europe

This list and the xml file will be updated when other WSDBs are qualified.



TV White Space Database for the Philippines

Powered by NICT technology

Location: Latitude: 10.3172 Longitude: 123.8906

Device type: Fixed, Portable

Available/Non-available channel list

| Channel Number | Availability |
|----------------|--------------|
| 2 | Available |
| 3 | Available |
| 4 | Available |
| 5 | Available |
| 6 | Available |
| 7 | Available |
| 8 | Available |
| 9 | Available |
| 10 | Available |
| 11 | Available |
| 12 | Available |
| 13 | Available |
| 14 | Available |
| 15 | Available |
| 16 | Available |
| 17 | Available |
| 18 | Available |
| 19 | Available |
| 20 | Available |
| 21 | Available |
| 22 | Available |
| 23 | Available |
| 24 | Available |
| 25 | Available |
| 26 | Available |
| 27 | Available |
| 28 | Available |
| 29 | Available |
| 30 | Available |
| 31 | Available |
| 32 | Available |
| 33 | Available |
| 34 | Available |
| 35 | Available |
| 36 | Available |
| 37 | Available |
| 38 | Available |
| 39 | Available |
| 40 | Available |
| 41 | Available |
| 42 | Available |
| 43 | Available |
| 44 | Available |
| 45 | Available |
| 46 | Available |
| 47 | Available |
| 48 | Available |
| 49 | Available |
| 50 | Available |
| 51 | Available |

Map | Satellite

IEEE 802.11af system



RF board



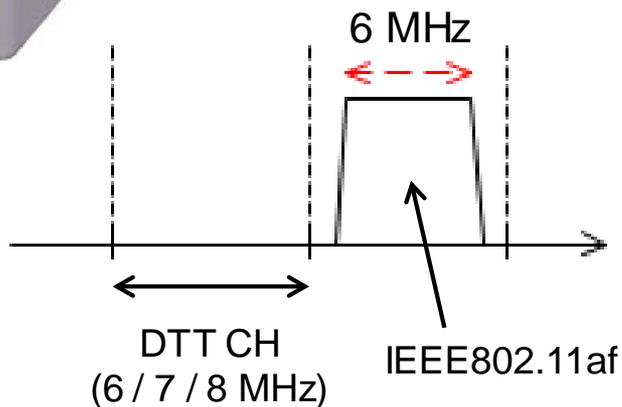
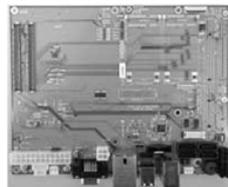
AD/DA board



Baseband board

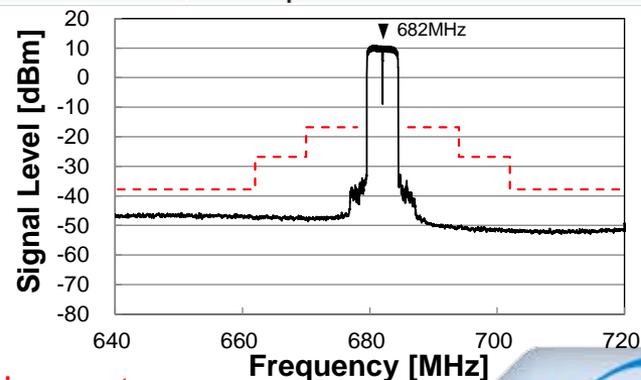


CPU board



| Item | Description |
|------------------------------|--|
| Frequency range | 470-710 MHz / 500~710 MHz |
| Channel bandwidth | 6 MHz |
| Channel step | 1MHz |
| Signal bandwidth | 4.83 MHz |
| Frequency accuracy | ± 2 ppm |
| Tx power | +10 / +30 dBm |
| Tuning range of output power | > 40 dB |
| Receiving signal PWR range | -88 ~ -20 dBm |
| Modulation | BPSK, QPSK, 16-QAM, 64-QAM |
| Error correction | Convolutional code (coding rate: 1/2, 2/3, 3/4, 5/6) |
| Multiple access | CSMA/CA |
| Multiplexing | OFDM |
| FFT size/clock | 128 points / 5.33 MHz |

| Device class | ACLR (dB) | | | | |
|------------------------|-----------|----|----|----|----|
| | 1 | 2 | 3 | 4 | 5 |
| $n = \pm 1$ | 74 | 74 | 64 | 54 | 43 |
| $n = \pm 2$ | 79 | 74 | 74 | 64 | 53 |
| $n \geq +3, n \leq -3$ | 84 | 74 | 84 | 74 | 64 |



ACLR (Adjacent Channel Leakage Ratio) conforms with ETSI requirement.

LTE system for TVWS

- Ready to operate in TVWS.
- Reconfigurable bandwidth (5/10/20 MHz) according to traffic congestion and TVWS availability.

Spectrum masks of the devices satisfy the **ETSI regulation** on out-of-band emission.



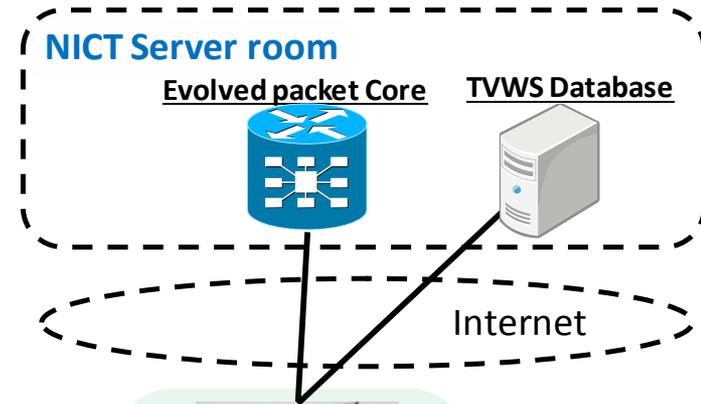
Femto cell eNB
for portable deployment



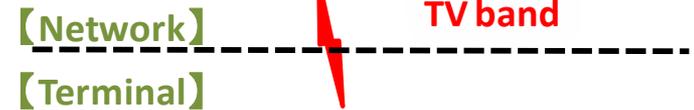
Wireless router
to convert between
LTE in TVWS and
Wi-Fi in 2.4/5GHz



Smartphone
supporting both
commercial and
TVWS bands

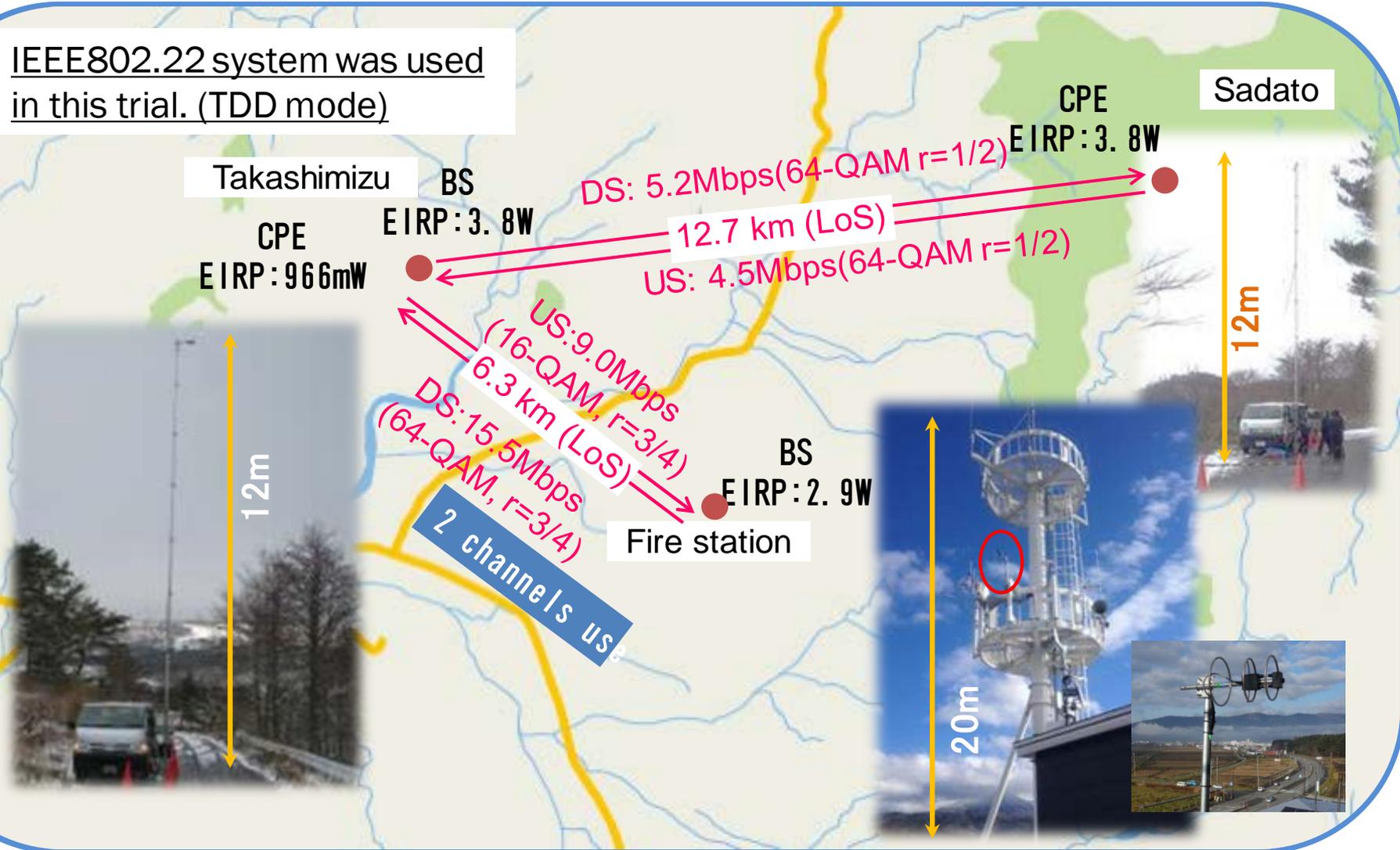


LTE eNB for TVWS



Trial in Japan (P2P over long-distance)

IEEE802.22 system was used in this trial. (TDD mode)



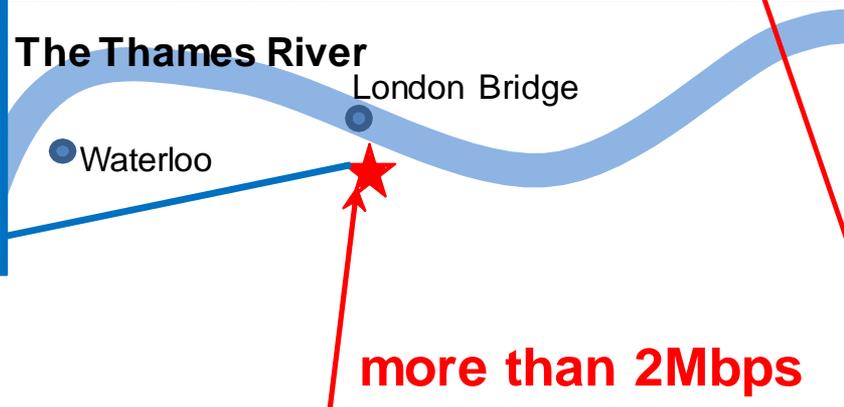
This experiment was conducted jointly with Hitachi Kokusai Electric.

Trial in London (P2P in metropolitan area)

IEEE802.11af system was used in this trial.



3-element Ring Yagi (7.4dBi)



more than 2Mbps over 3.7 km



This experiment was conducted with Dr. Oliver Holland and his colleagues from King's College London.

- In India, residential area is organized from very small unit of villages
- Not practical to deploy cables to homes
 - ▶ Internet is NOT available just 50 km away from the metropolitan area
 - ▶ Even phone call is difficult depending on locations
- Trial
 - ▶ Motivation: TV White Space could be a solution to the digital divide problem
 - ▶ Collaborative research with IIT Bombay
 - ▶ Using White Space LTE system

TV White Space communications for rural areas — Experiments in India —

- Technologies and standardizations are ready to start up operations in TV White Space
 - ▶ Feasible deployments
 - ▷ Point-to-Point link (front-haul/back-haul)
 - ▷ Mobile communications
 - ▶ Solutions expected
 - ▷ Traffic off-loading from commercial 3G/4G (LTE) bands
 - ▷ Mitigation of Digital divide problem
- **What is next step?**
 - ▶ to check **feasibility and issues** in various use cases according to demands and circumstances in each country
 - ▶ to consider radio regulations and business deployment scenarios