One solution for a seamless positioning, IMES concept and compatibility with GNSS signals

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Are you looking for a solution for the seamless positioning?

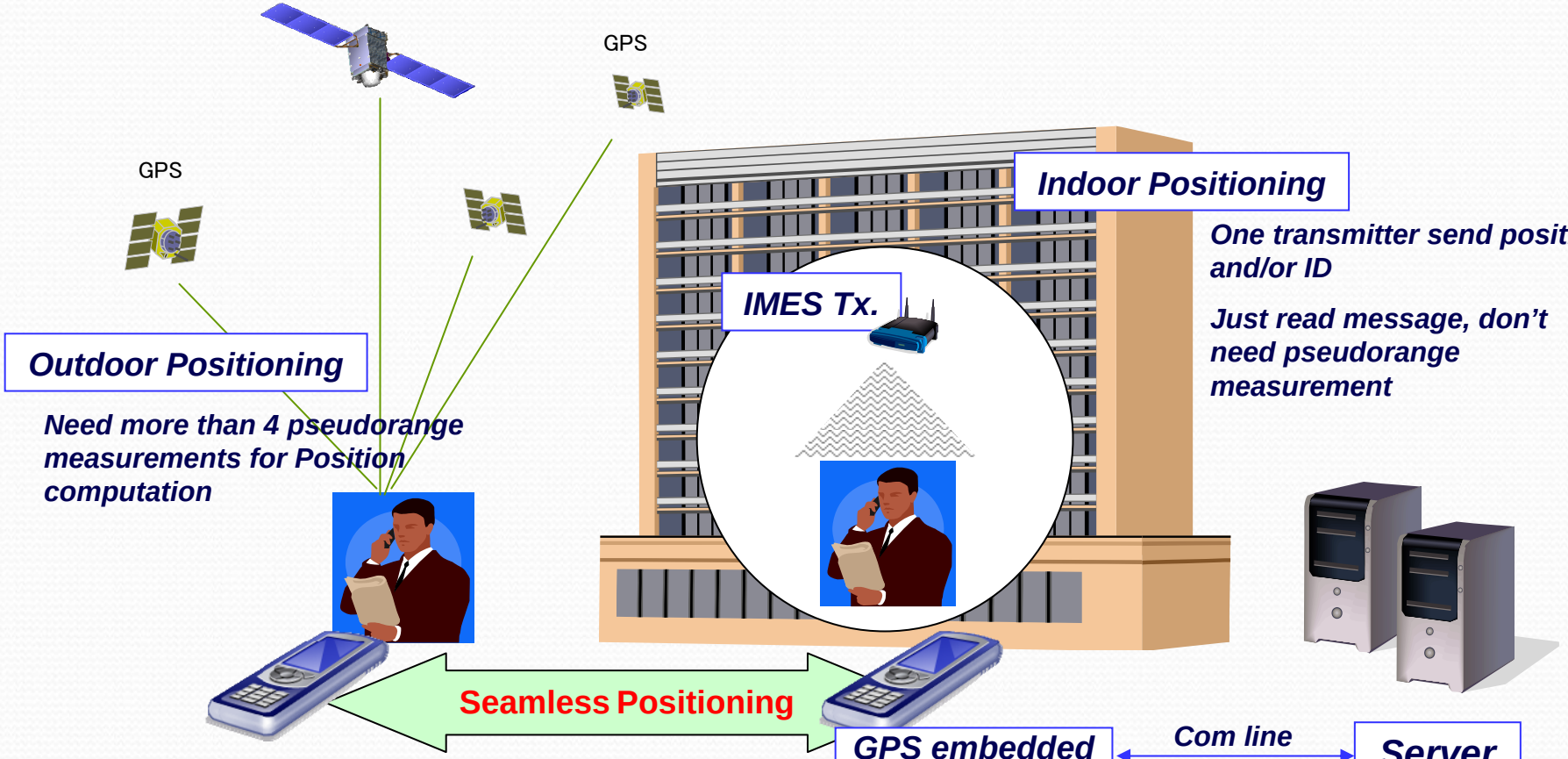
- How many hours do you spend indoor during your daily life?
  - Most people spend their life much longer time indoor than outdoor
- Growing smart phone and LBS market require seamless positioning
  - at any condition
  - at any location
  - at any time

Indoor MEssaging System (IMES) is a powerful solution for realization of seamless positioning.

Concept of IMES

- IMES can transmit its position in three dimensions and/or ID directly
  - No pseudorange measurement and time synchronization.
- Moderate accuracy (10-20m), but stable even in deep indoor.
  - Signal reception area equals to position accuracy.
- Signal is still compatible and interoperable with GPS/QZSS signal for seamless positioning
  - The same GNSS chipset can acquire signals from satellites as well as IMES Tx without serious modifications on existing chipset software. (No change on H/W design)
- Target users are cell-phone, smart-phone and handheld receiver with low dynamics.

Seamless positioning between Indoor and outdoor with common GPS chipset



IMES signal characteristics

Signal Properties of GPS & IMES

	GPS	IMES
Center Frequency	1575.42MHz	1575.42MHz +/- 8.2kHz
PRN ID	1-32	173-182
PRN Code Chip Rate	1.023MHz	1.023MHz
PRN Code Length	1ms	1ms
Data Rate	50bps	50bps
Modulation	BPSK	BPSK
Polarization	RHCP	RHCP

- The power of transmitter is
  - less than defined figure as Japanese radio regulation (-94.35dBW) .
  - set value NOT over specified MAX receiving power strength at the user anntena input.

PRN Code for IMES

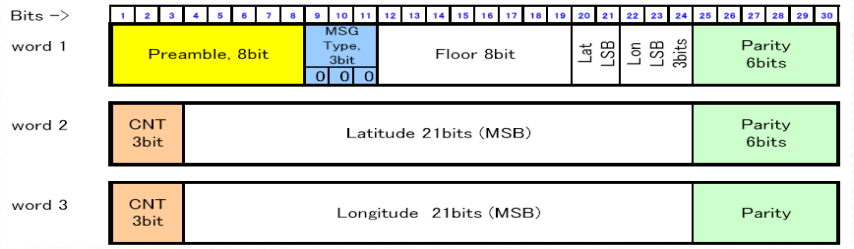
- 10 PRN Codes in 210 C/A codes which the US GPS maintained its allocation table were assigned for IMES in November 2007
  - http://www.losangeles.af.mil/shared/media/document/AFD-101124-042.pdf

PRN Signal Number	G2 Delay (Chips)	Initial G2 Setting (Octal)	First 10 Chips (Octal)	PRN Allocations	Orbital Slot
173	150	1362	415	QZSS – IMES3	Ground
174	395	1654	123	QZSS – IMES3	Ground
175	345	510	1267	QZSS – IMES3	Ground
176	846	242	1535	QZSS – IMES3	Ground
177	798	1142	635	QZSS – IMES3	Ground
178	992	1017	760	QZSS – IMES3	Ground
179	357	1070	707	QZSS – IMES3	Ground
180	995	501	1276	QZSS – IMES3	Ground
181	877	455	1322	QZSS – IMES3	Ground
182	112	1566	211	QZSS – IMES3	Ground
183	144	215	1562	QZS1	A1
184	476	1003	774	Reserved (QZS	TBD

NOTE: PRN codes are currently allowed to use only in JAPAN.

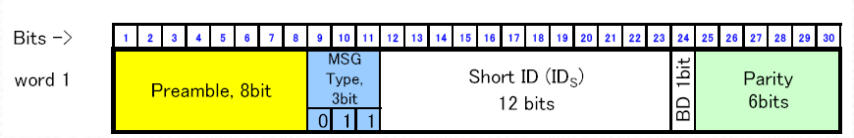
Message structure of IMES

- is defined in the annex of IS-QZSS.
  - Similar to QZSS and GPS L1C/A message structure,
    - use 30bit/word
  - Four types of IMES messages are defined currently.
    - #0 and #1; Absolute position
      - Longitude, Latitude, Floor and/or Hight
      - Difference is resolution
    - #3 and #4; position ID
      - #3 for LBS managed by operators
      - #4 for local server connection
    - #0 or #1 and #3+#4 are transmitted flexible sequence



#	Content	Bit Length	LSB		Range minimum	~	maximum
1	Floor	8	1 th		−50 th	~	204 th
2	Latitude	23	2.1E−05 deg	(2.39 m)	−90 deg	~	90 deg
3	Longitude	24	2.1E−05 deg	(2.39 m)	−180 deg	~	180 deg

Message #0, Position Data, 3-Word Frame



Message #3, Short ID, 1-Word Frame

- Four message types are reserved for future applications

Applications

- Location Based Service
  - Check in service
  - Location based Advertisement.
- Disaster Management, rescue support
  - Evacuation support, and effective rescue underground mall, huge shopping mall complex, department store and so on.
- Provide DR reference point to reset INS sensor.
  - Spot IMES transmitters are installed at revolving doors, elevator halls, entrance doors into room.
- Tracking service for children, asset, entrance control into security area, and more

Avoiding Interference to GPS

- **Compatibility with GPS is Vital for IMES**
  - IMES gets real power when it goes together with GPS, broadcasting signals of the same properties as the pioneer of the global navigation satellite system.
  - IMES has not spared any effort to make sure **not** to give a harmful interference to GPS.

NAVSTARs

Where GPS and IMES meet

IMES will be operated “indoors” including by the window and building entrances. They are where the two positioning systems are expected to work seamlessly.

IMES Transmitters

“Open Sky”

Received Signal Strength:
-158.5dBW
(minimum, as specified in IS-GPS)

“by the Window”

Received Signal Strength:
say, **-165dBW**

“Deep Indoor”

Received Signal Strength:
almost none

Two-Step Measures against Interference

Measure 1

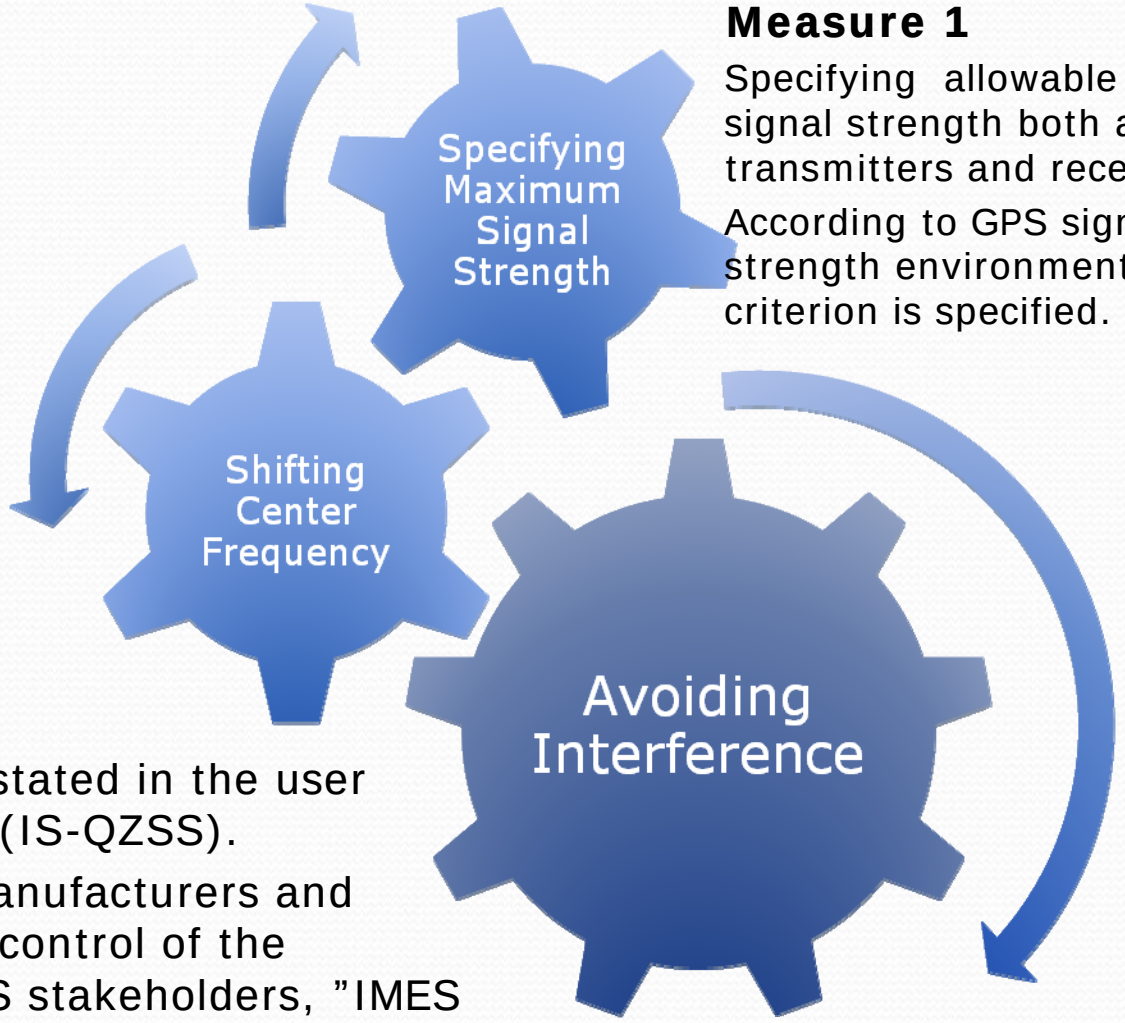
Specifying allowable maximum signal strength both at transmitters and receivers.

According to GPS signal strength environment, different criterion is specified.

Measure 2

Shifting the center frequency of IMES carrier wave by +/-8.2kHz from GPS L1.

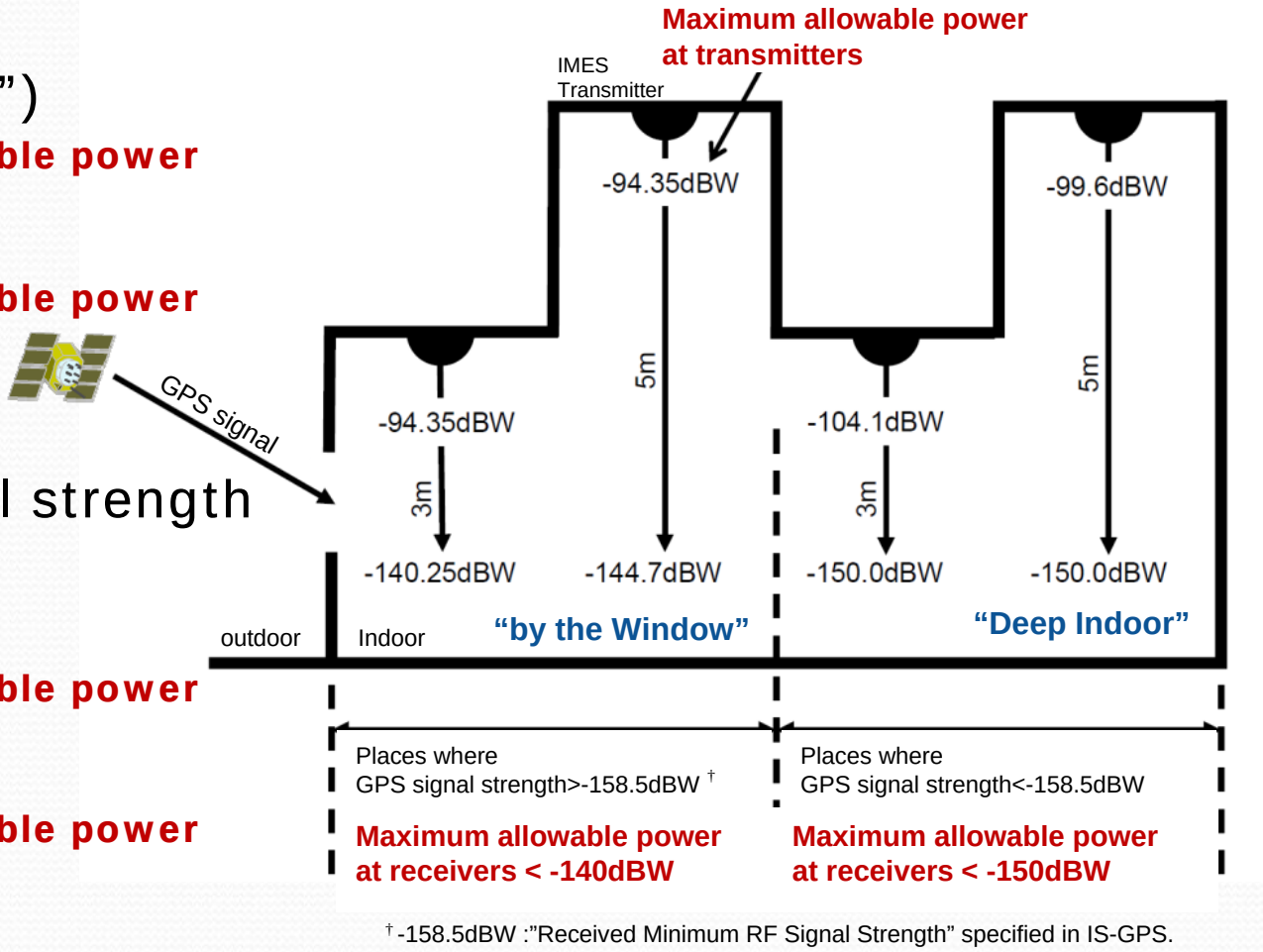
This measure is the description to raise the safety margin for high sensitivity receivers



- Both measures are stated in the user interface document (IS-QZSS).
- IMES transmitter manufacturers and installers are under control of the organization of IMES stakeholders, ”IMES consortium”.

Measure 1:
Specifying Allowable Maximum Signal Strength

- where GPS signal strength >-158.5dBW ("by the Window")
  - **Maximum allowable power at transmitters < -94.35dBW**
  - **Maximum allowable power at receivers < -140dBW**
- where GPS signal strength <-158.5dBW ("Deep Indoor")
  - **Maximum allowable power at transmitters < -94.35dBW**
  - **Maximum allowable power at receivers < -150dBW**



† -158.5dBW :"Received Minimum RF Signal Strength" specified in IS-GPS.

As defined in IS-QZSS Annex
http://qz-vision.jaxa.jp/USE/is-qzss/DOCS/IS-QZSS_13_E.pdf

Measure 2:
Shifted Center Frequency from GPS L1

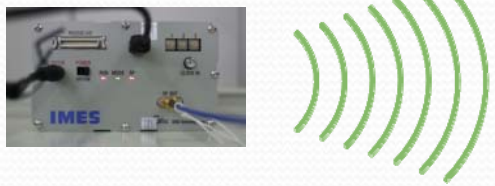
"I'll be stepping aside … just slightly."

The center frequency of IMES carrier wave is shifted by **+8.2kHz or -8.2kHz** from GPS L1.

GPS

1575.42MHz

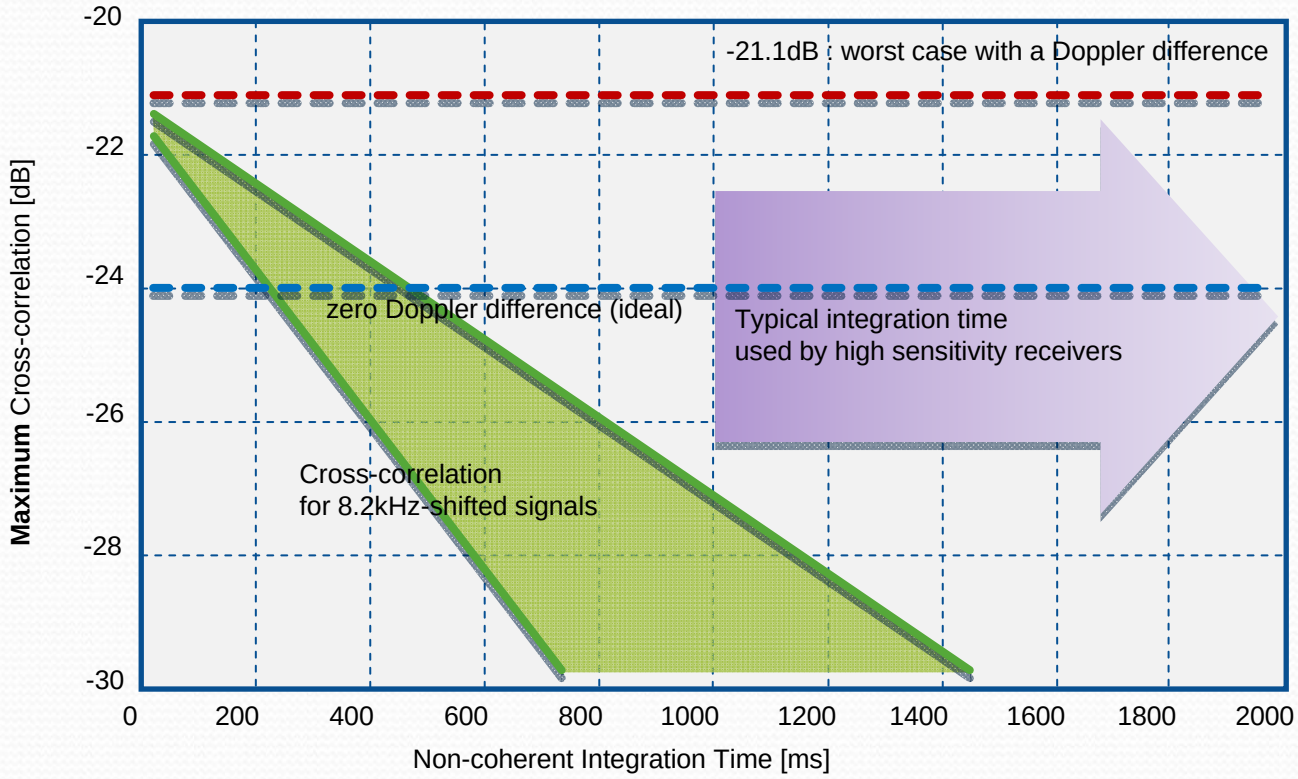
IMES

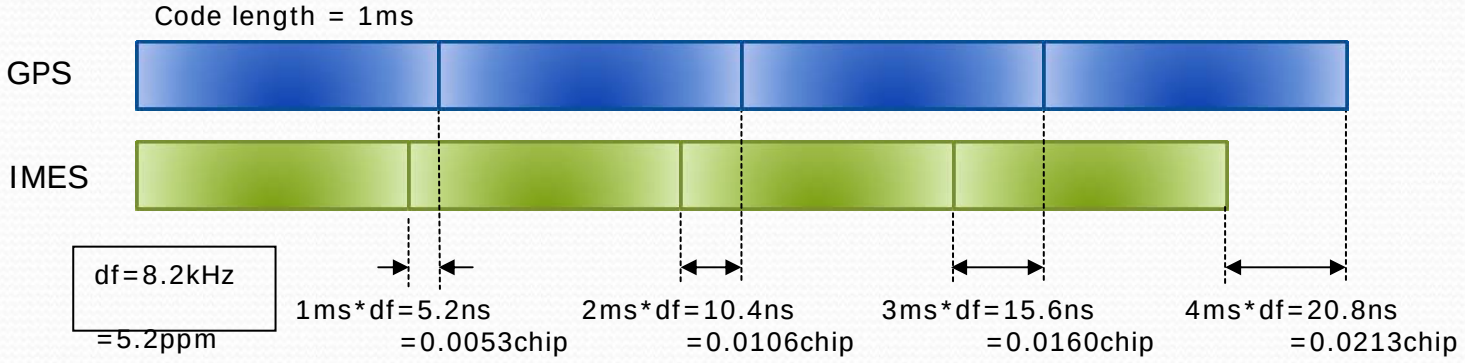


1575.4282MHz or
1575.4118MHz

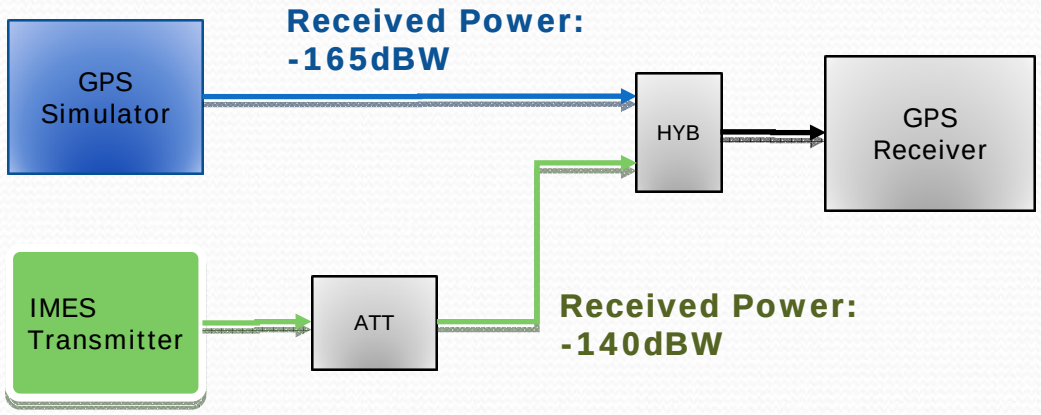
Especially for high sensitivity receivers, this measure improves cross-correlation between the PRN codes of GPS and IMES by several dBs and raises the safety margin.

Measure 2:
How Shifted Center Frequency work?





Experiment results – Fix Rate



Making the receiver "Cold Start" when IMES signal exists

Examine if the receiver fixes the positioning

Good ☺ :

Establish positioning within 60sec.

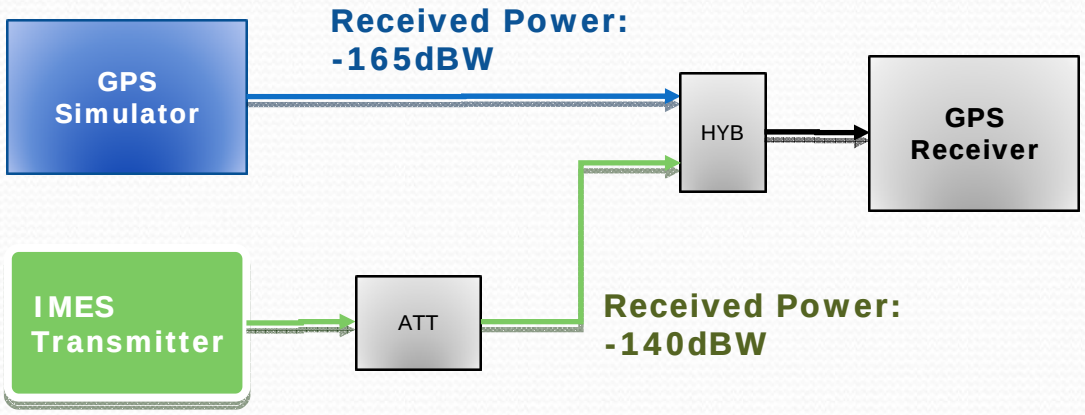
NG ☹ :

No positioning after 60sec.

	NO IMES	IMES with center frequency @ 1575.42MHz	IMES with center frequency @ 1575.42MHz +/- 8.2kHz
Fix Rate	100%	91%	**100%**

Number of attempt = 50

Experiment results – TTFF



Making the receiver "**Hot Start**" when IMES signal exists

Examine the time to first fix

	NO IMES	IMES with center frequency @ 1575.42MHz	IMES with center frequency @ 1575.42MHz +/- 8.2kHz
TTFF	16.6sec	24.8sec	**13.1sec**

Number of attempt = 50

In "by the window" environment, no interference is confirmed, verifying the two-step measures do work effectively.

GPS – IMES Compatibility Demonstration

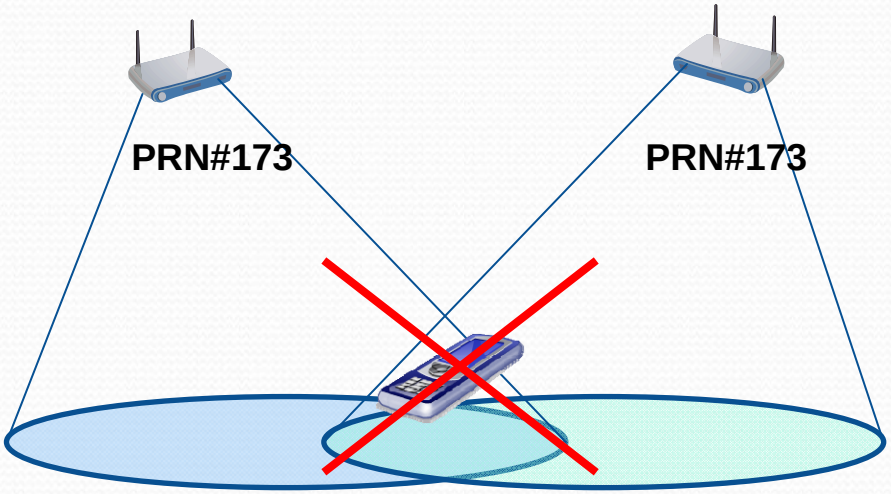
- Demonstrations to be staged three times on 8 Sept. during:
  1) 11:00 – 11:15 JST : Morning break
  2) 13:15 – 14:15 JST : Lunch time
  3) 16:15 – 16:30 JST : Afternoon break

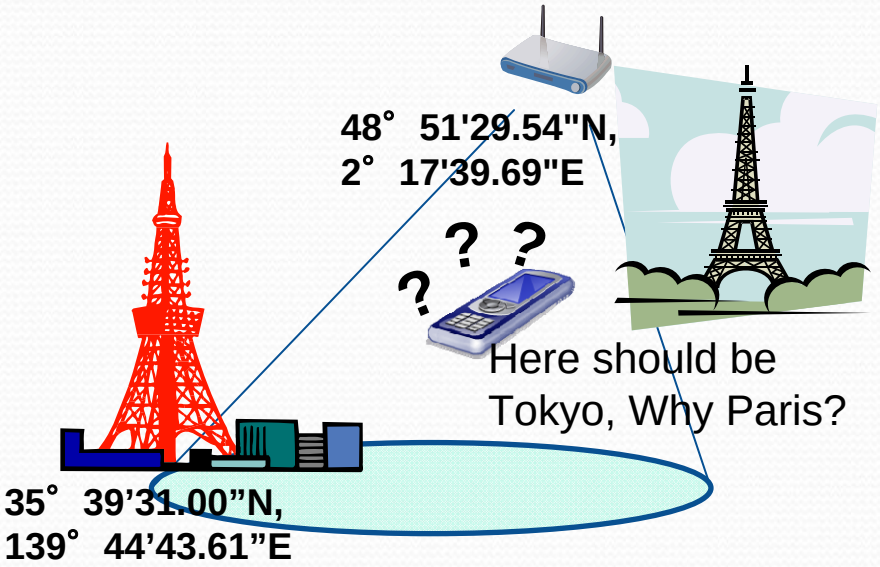
  at Reception Hall
- Using High sensitivity Rx wired with GPS simulator and IMES Tx
- Examine
  - TTFF and C/N0

Case	GPS URP	# of GPS	IMES URP	IMES PRN
Open sky	-158.5 dBW	8 to 9	-140 dBW	173
By the window	-165 dBW	4	-140 dBW	173
Deep Indoor	-180 dBW	2	-150 dBW	173

Why should IMES Tx be controlled?

- To avoid interference between IMES signals.
- To prevent misuse on purpose or accidentally.
  - setting signal strength beyond specified value
  - transmitting wrong position





PRN Code management(1/2)

- PRN code assignment for each Tx devise.
  - to avoid overlapping same PRN code between neighboring cells.
- Installer or Tx manufacturer should register following set of Tx configuration to get PRN code:
  - Tx product number
  - location to be installed
  - broadcasting coordinate value
  - Tx EIRP
- Broadcasting position will be registered to “Location Information code database” managed by Geospatial Information Authority in Japan (GSI), simultaneously.

PRN Code management(2/2)

- Life cycle control will be required
  - To facilitate preventing misuse
  - Tx should be traced its location and owner/manager during whole life cycle after shipment, from installation to disposal.
- JAXA is taking a role to establish the framework of IMES PRN code management and implement transiently until operational management organization is established.
  - Operating procedure for the PRN code management is now being prepared.

Further JAXA's Works

- Finalization of technical specifications
  - Shortening of the time to read message
    - Message data rate change from 50 bps to 250 bps or more is under investigation.
    - Switching algorithms between outdoor GNSS tracking and indoor IMES tracking.
  - Message type definition
- Developing efficient management scheme and method
  - Operation procedure for PRN code management
  - Installation standard/guideline

Summary

- IMES is a solution for realization of seamless positioning.
- Two step measures are taken to avoid interference to GNSS signals
  - Specifying allowable maximum signal strength
  - Shifting the center frequency of IMES
- PRN code management procedure is being prepared by JAXA to prevent misuse on purpose or accidentally.

Thanks a lot for your attention!