IMES (Indoor Messaging System) A Proposal for New Indoor Positioning System

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What is IMES ?

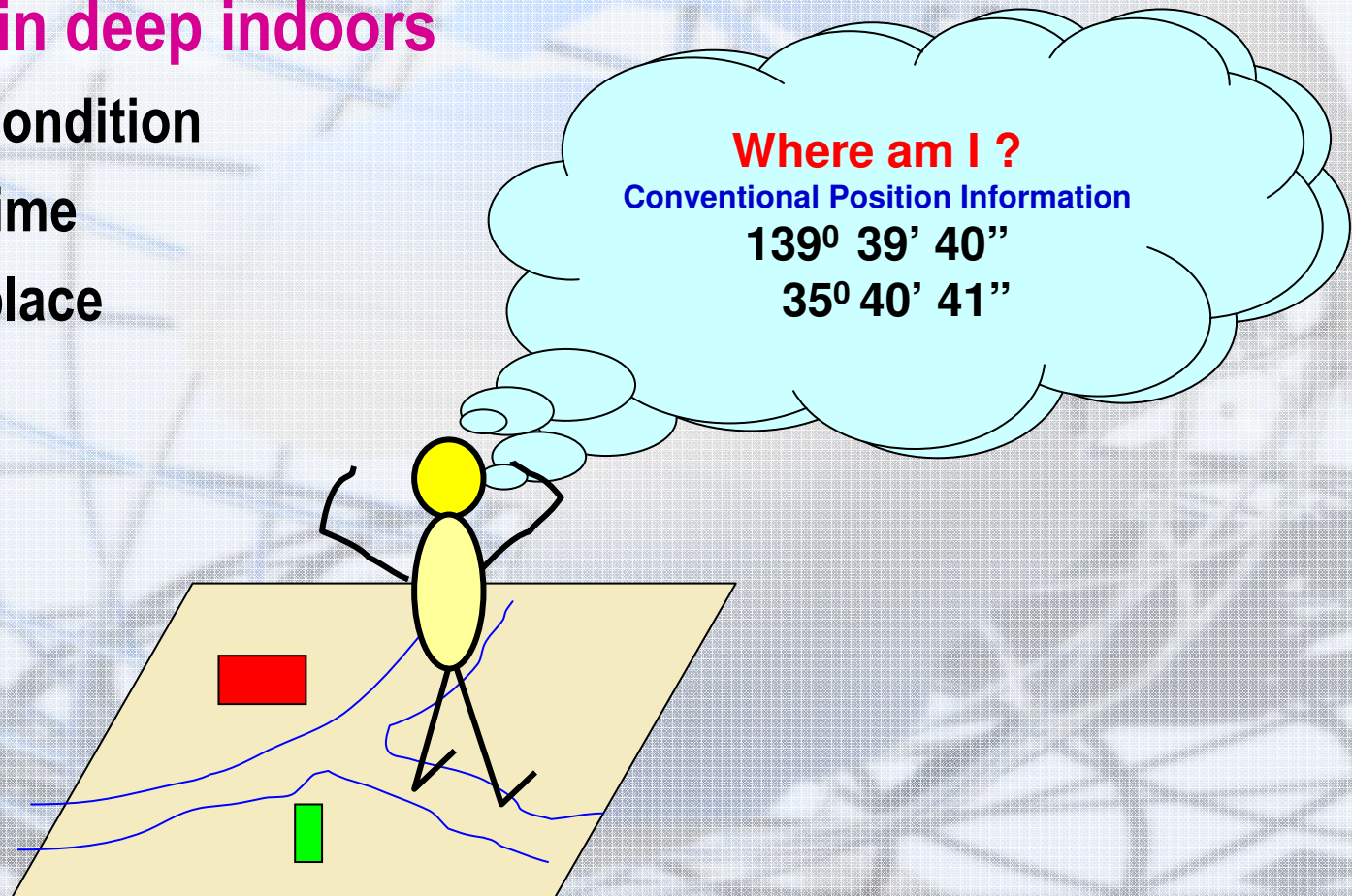- **IMES stands for**
  - **Indoor MEssaging System**

- **It transmits the position data itself in the Navigation Message**

Fundamental Problem

How to know my location precisely ?

– **Specially in deep indoors**

- **At any condition**
- **At any time**
- **At any place**

Where am I ?
Conventional Position Information
139^0 39' 40''
35^0 40' 41''

Background - 1

- **Japanese E911 legislations were enforced in April 2007**
  - **More than 100 Million cell-phones with GPS receiver in Japan in a couple of years**

- **Number of mobile phones in the world : 3.3bil. by NOV 2007**
  - **Penetration Factor 49% → Near to Half the world's population,**
  - **Expected Penetration Factor 61% → By the end of 2008**
  - **An average growth rate of 24% for the past eight years**
    - Source: http://en.wikipedia.org/wiki/Mobile_phone#cite_note-9
    - http://www.guardian.co.uk/technology/2008/sep/26/mobilephones.unitednations
    - http://www.chinapost.com.tw/business/global%20markets/2008/05/26/158188/Mobile-phone.htm

- **LBS market is expected to grow drastically**

- **Seamless positioning is one of the most important requirements for commercial applications.**
  - **Several approaches**
    - RF ID, WiFi, UWB, Pseudolite, Repeater and so on….. And of Course ultimately IMES

Background – 2 (USA Scenario)

- **262mil. of wireless users in USA as per June 2008**
  - **60mil. addition compared to June 2005**
    - CTIA Report

- **296K E911 calls per Day in Jun 2008**
  - **36K addition compared to June 2005**
    - CTIA Report 16% of US Houses are Wireless-only as per June 2008
  - **This forces operators to develop methods to provide E911 callers' position using mobile networks only**
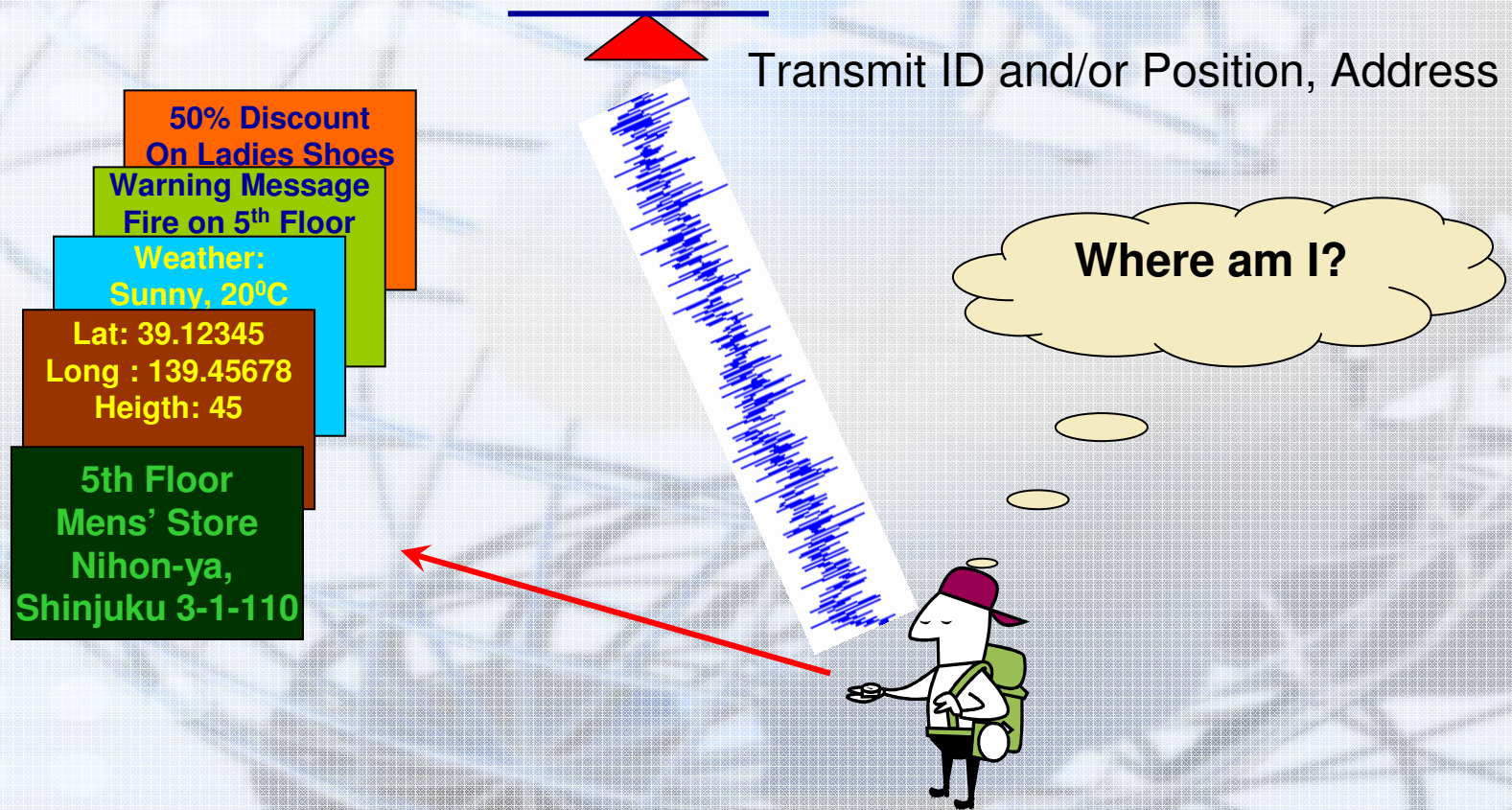   - CTIA Report

Background - 3

- **There are other indoor navigation systems like A-GPS, E-GPS and Pseudolites etc**
  - **But they have unstable accuracy**
    - **The accuracy varies case by case from few meters to few hundreds of meters**
  - **Complex architecture**
  - **Difficulty in deep indoors**
  - **During emergency, a search in 3-D space in 100m accuracy is not a good figure**
  - _**How to know that the victim is on the 15th Floor, Room No 1510 precisely?**_

IMES Concept - 1

Principle of Proposed IMES System

Transmit ID and/or Position, Address

50% Discount
On Ladies Shoes

Warning Message
Fire on 5th Floor

Weather:
Sunny, 20°C

Lat: 39.12345
Long : 139.45678
Heigth: 45

5th Floor
Mens' Store
Nihon-ya,
Shinjuku 3-1-110

Where am I?

IMES Concept - 2

- **IMES can transmit its position in three dimensions directly**
  - **No pseudorange measurement and time synchronization**
- **Compatible and interoperable signal with GPS/QZSS for seamless positioning**
  - **The same Receiver can acquire signals from satellites as well as indoor transmitters without serious modifications on existing receiver.**
  - **It can be upgraded to future GNSS signals**
- **Target users are cell-phone and handheld receiver with big mass volume and low dynamics.**

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Signal Design Concept

- **Compatible and interoperable with GPS/QZSS signals for seamless positioning**
  - **The same Receiver can acquire signals from satellites as well as from IMES**
    - **This means similar signal structure**
- **Different Message Types based on Application Types**
- **Low power consumption**
  - **Longer run of cell phones**
- **Stable Accuracy**
  - **Sub-meter accuracy is not required. 10m seems to be enough for users to know where they are**
    - **moderate room size, each shop or portion in shopping complex**
  - **Stable position data at any time is more important than higher precision**

RF Properties of IMES

- **Same as GPS L1 C/A for minimizing receivers' modifications**

RF Centre Frequency	1575.42Mhz (+/- Δf)
PRN Code Rate	1.023Mhz
PRN Code Length	1ms
PRN ID	**173 – 182**
Navigation Message Rate	50bps
Modulation	BPSK
Polarization	RHCP

- **The power of transmitter is**
  - less than the value defined by radio regulation
  - is varied with environment of the locations and space between transmitters

PRN Code Table for IMES

- *The US Government has allocated 10 PRN Codes for IMES*
  - *C/A PRN CODE ASSIGNMENTS as of Nov. 5, 2007*
  - *http://www.losangeles.af.mil/shared/media/document/AFD-070530-036.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

Auto and Cross Correlation between IMES PRN Codes
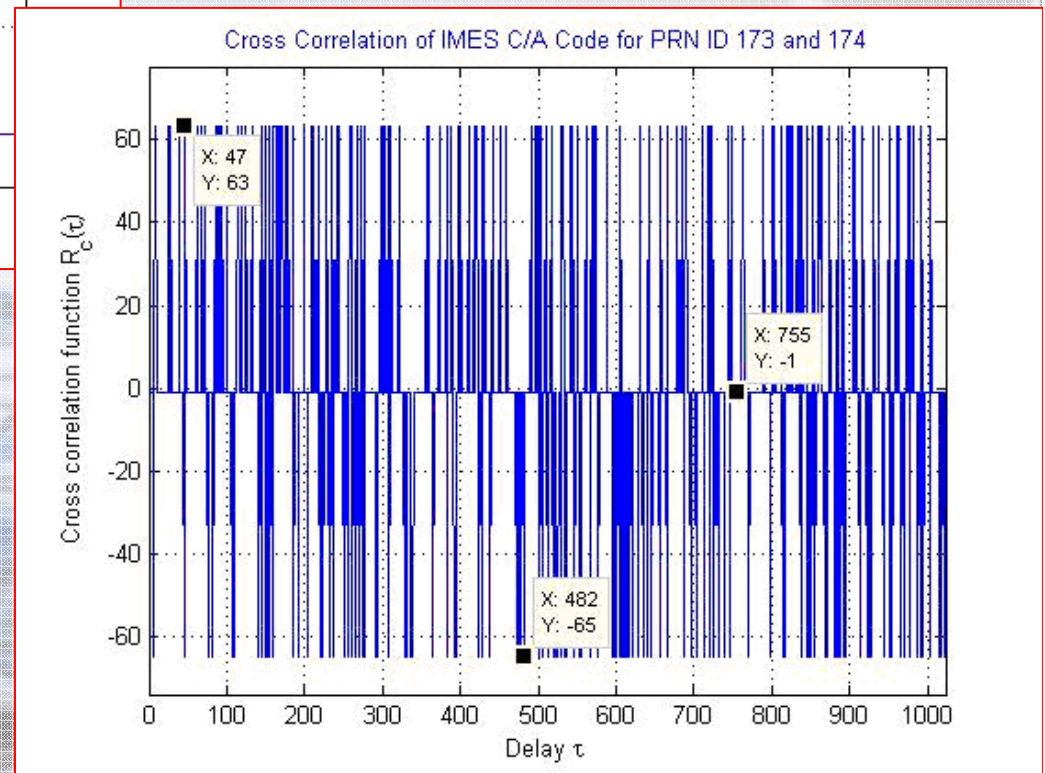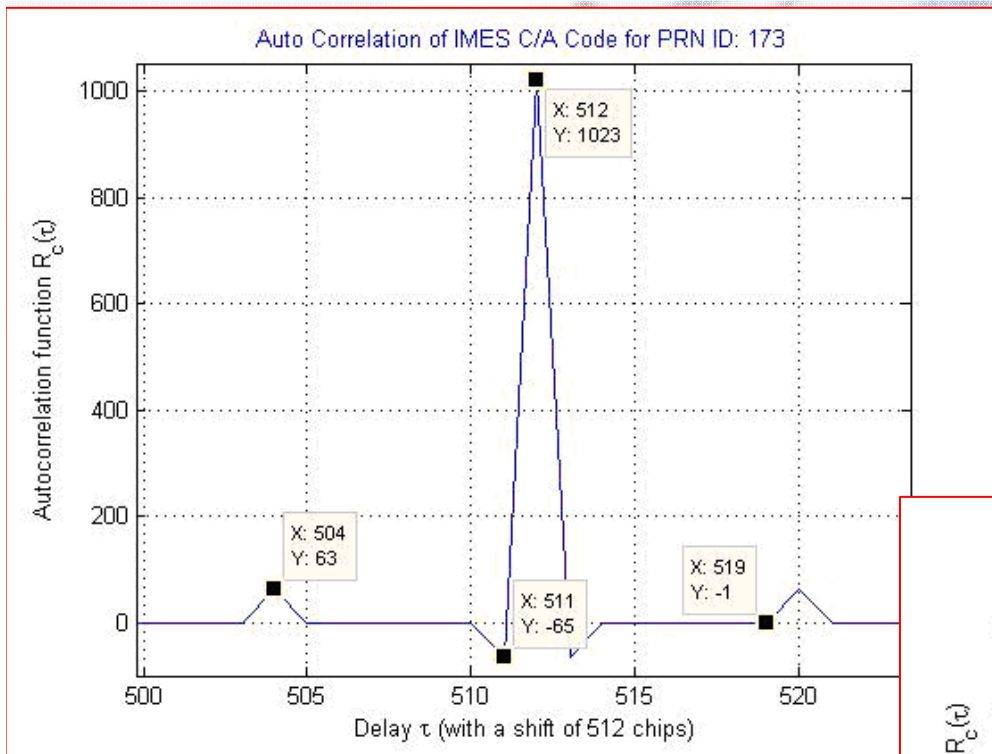
IMES Message Structure

🐝 **The message structure of IMES is defined in the annex of IS-QZSS.**

– **Similar to QZSS and GPS L1C/A message structure**

– **Four types of IMES messages are defined currently**

- **Type #0: Longitude, Latitude, Floor ID, [90bit,1.8 sec]**
- **Type #1: Longitude, Latitude, Height, Floor [120bit, 2.4 sec]**
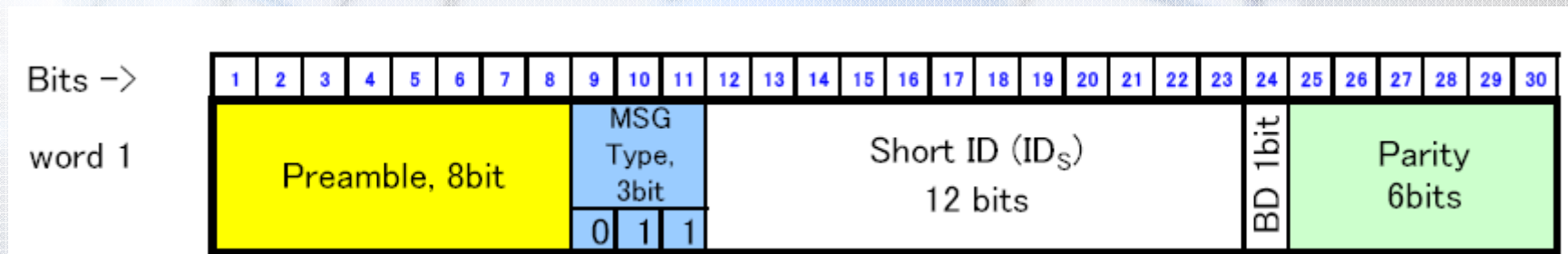- **Type #3: Short ID [30bit, 0.6sec]**
- **Type #4: Medium ID [60bit, 1.2sec]**

IMES Message
Type # 1, 3-D Position Format with Floor ID
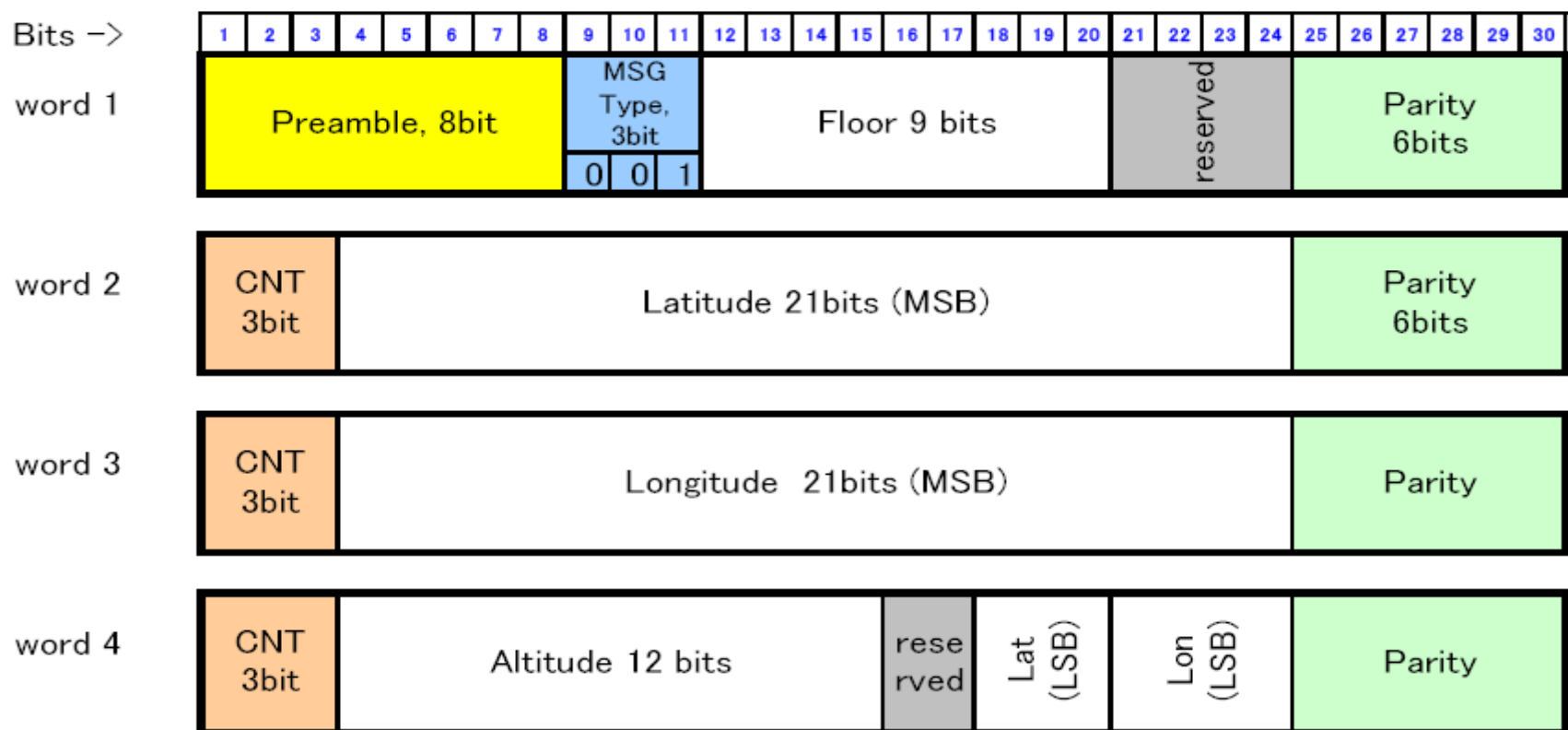
#	Content	Bit Length	LSB		Range		
					minimum	~	maximum
1	Floor	9	0.5 th		−50 th	~	205 th
2	Latitude	24	1.1E−05 deg	(1.19 m)	−90 deg	~	90 deg
3	Longitude	25	1.1E−05 deg	(1.19 m)	−180 deg	~	180 deg
4	Altitude	12	1 m		−95 m	~	4000 m

IMES Message
Type #3, Short ID Format

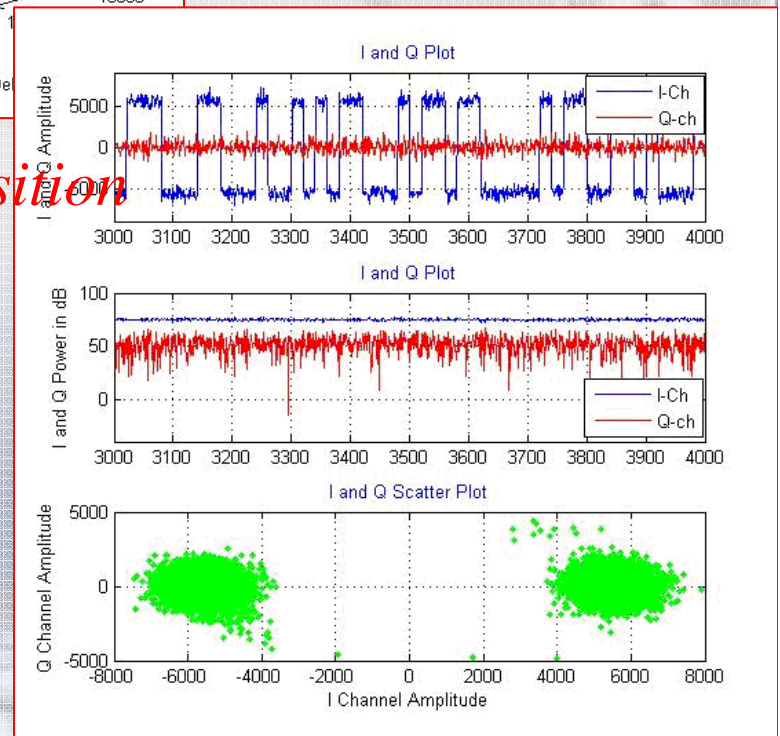# IMES Control Software

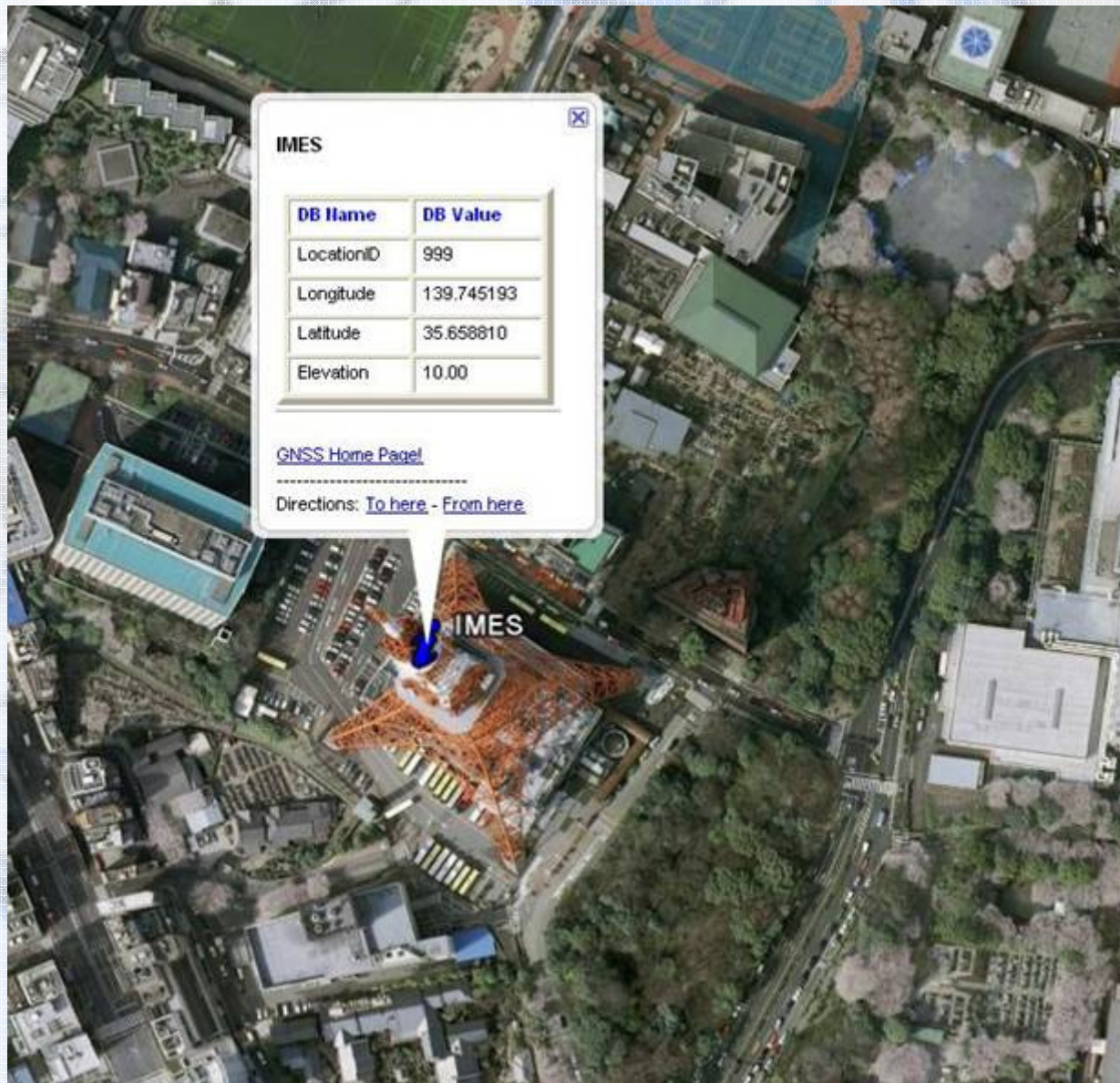# IMES Signal Acquisition and Tracking

IMES IF Signal
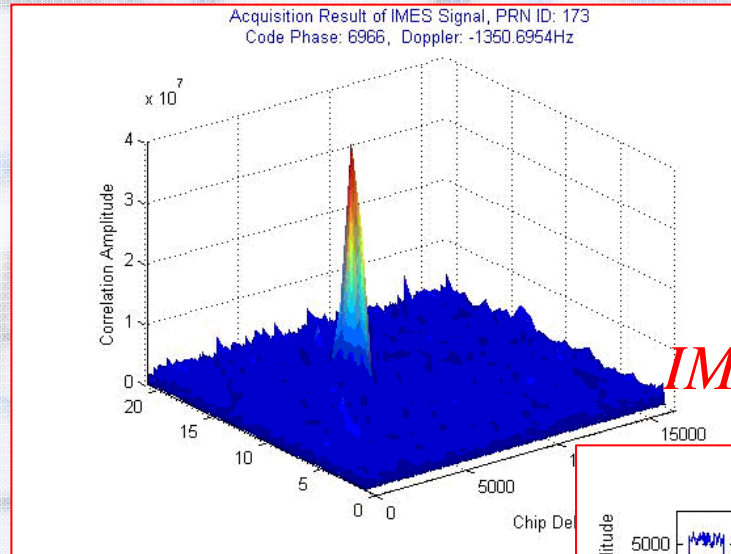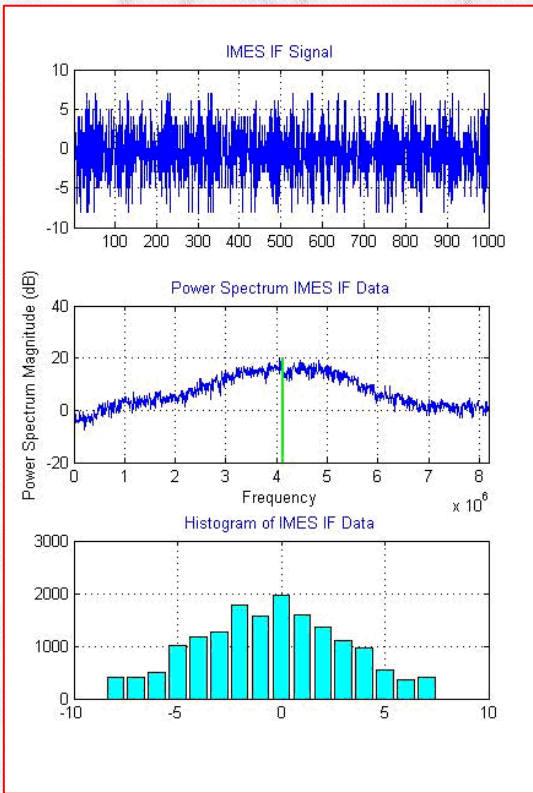
IMES Signal Tracking

IMES Signal Acquisition

IMES Output Position Data

Experiments & Demonstration

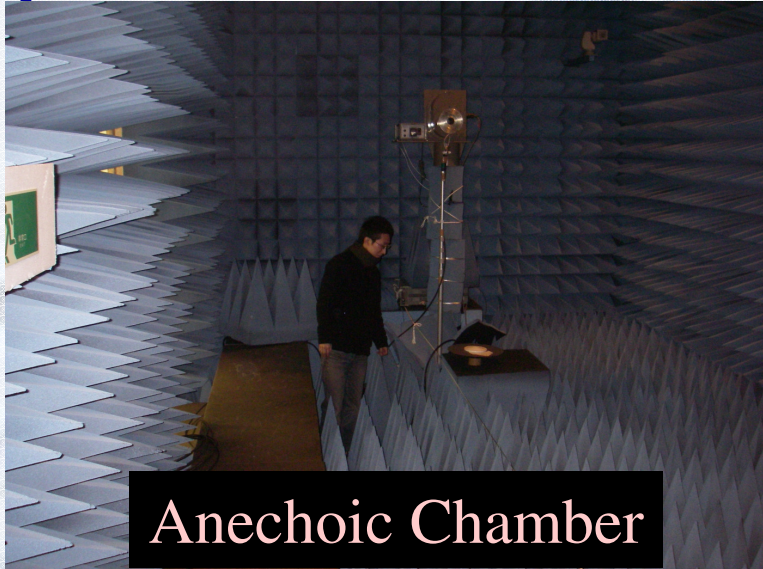**Indoor Demonstration at Underground Parking**
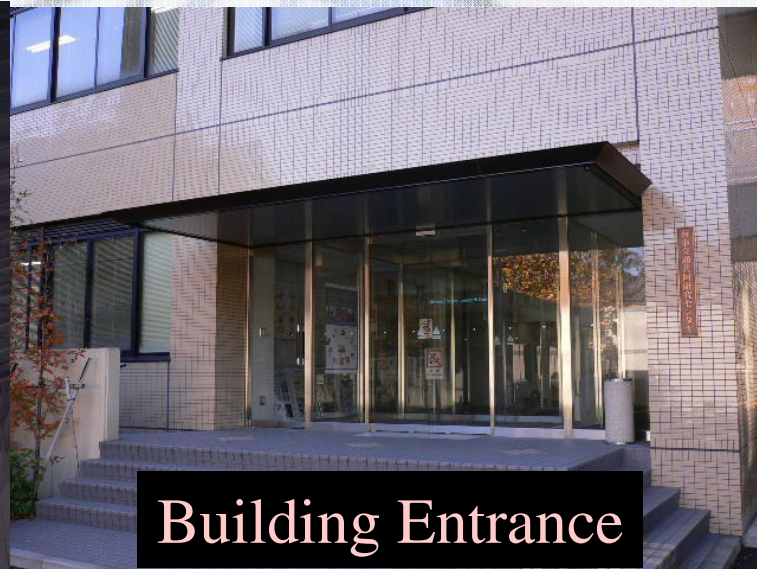

IMES Enabled Cell Phone

Observation using Mobile Phone

Experiments Conducted at Various Locations

Anechoic Chamber

Building Entrance

Office Room

Building Entrance

Public Facility Location

Department Store, Shoe Section

Railway Stations

Department Store

Summary - 1

* **The concept of IMES for seamless navigation is introduced.**
    * **Requires No ranging**
    * **Requires No synchronization**
    * **Requires Only single unit for 3D position & messages**
    * **Requires No H/W change for existing GPS**
    * **Applicable to any cellphone globally with GPS chip**
    * **Applicable to any GNSS signal type**
    * **Provides seamless position, anytime, anywhere**

Summary - 2

- **The concepts and its feasibilities were demonstrated by experiments.**
  - **Demonstration at underground parkings, office buildings, building lobby etc**
  - **Interference experiments**
- **Patents related to IMES signal design, transmitter, receiver, data management and other related are filed internationally**
- **More interference related analysis are planned to fix detail specifications**

Thanks a lot !