Report of "*Seminar on GNSS Spectrum Protection and Interference Detection Mitigation*" during ICG Expert Meeting in December 2015

IDM Workshop on
GNSS Spectrum Protection and Interference Detection and Mitigation

Saint Tropez Hotel, Changsha, China

17 May 2016

MITOME, Takahiro

Co-Chair of the Compatibility and Spectrum Sub-Group

Overview (1 of 2)

- The ICG Experts Meeting on GNSS Services was held in December 2015
  - To increase knowledge and expertise relating to GNSS capabilities
  - To emphasize the benefits of GNSS to the world user community
- During this ICG Expert Meeting, a two-day seminar was held to describe the importance of GNSS spectrum protection
  - Introduction to the regulatory aspects of spectrum management
  - Discussion of technical aspects such as detection technologies and mitigation techniques of radio frequency interference

Overview (2 of 2)

- The ICG Experts Meeting had participants from more than 30 countries representing governments, colleges, research labs and space agencies etc..
- Through an interactive session at the beginning of the seminar, all participants recognized the benefits and importance of GNSS
- Interactive feedback at the seminar end confirmed that it had achieved the objective to inform participants about GNSS spectrum protection and the importance of good national spectrum management for continued access to GNSS benefits

Fundamentals of GNSS (1 of 2)

- A brief history of GNSS was provided
- GNSS navigation principles, its application, each GNSS system signals and receiver fundamentals were introduced.
- Through the interview, all participants agreed on the benefits and importance of GNSS.
- One important point - Since GNSS signals are weak compared to terrestrial radio sources, they are very susceptible to radio frequency interference (RFI). Therefore, it is necessary to protect GNSS signals through proper spectrum management to ensure economic benefits from having access to interference-free GNSS.

Fundamentals of GNSS (2 of 2)
- Signal Power Level Comparison -

- GNSS receivers expect to receive and can operate at signal levels even below the natural background radiation level, the "noise floor"
- **GNSS receivers** need a minimum power level "−130dBm"
- **Mobile phones** (eg GSM) expect a minimum "−104dBm"
  - **Around a thousand times higher than GNSS!**
- This difference in expected receive signal levels makes GNSS reception vulnerable to RFI

Interference and Spectrum Management (1 of 3)
Minimize Interference, Maximize Benefits

- In addition to the interference from co-primary radio services, other types of interference such as out-of-band emissions, spurious emissions and adjacent band interference should also be taken into account.
- To avoid interference, the ITU **Radio Regulations** (treaty material: See separated slides for details) allocate the spectrum appropriately (e.g., frequency separation, power constraints etc.)
- National implementations usually align with the ITU **Radio Regulations**

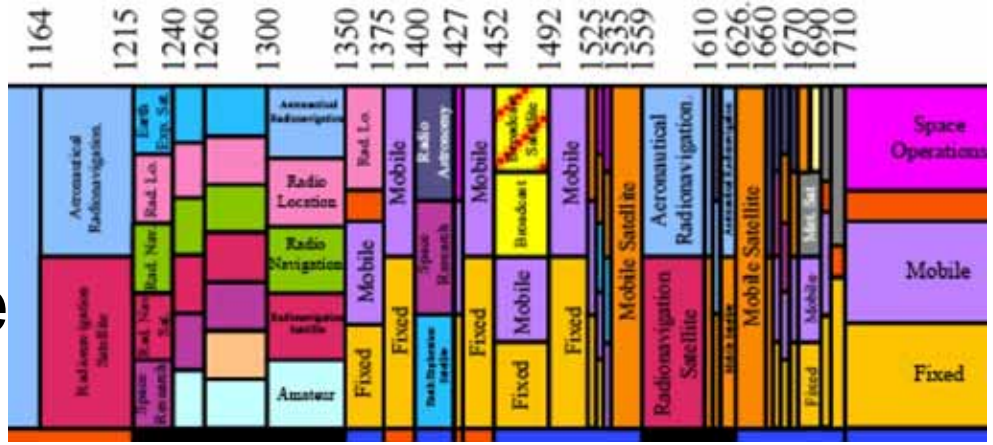
Interference and Spectrum Management (2 of 3)

Examples of Allocations (International, Domestic)

- Radio Regulations Allocations (L-band)

Allocation to services		
Region 1	**Region 2**	**Region 3**
1 525-1 530 SPACE OPERATION (space-to-Earth) FIXED MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Mobile except aeronautical mobile 5.349 5.341 5.342 5.350 5.351 5.352A 5.354	**1 525-1 530** SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Fixed Mobile 5.343 5.341 5.351 5.354	**1 525-1 530** SPACE OPERATION (space-to-Earth) FIXED MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A Earth exploration-satellite Mobile 5.349 5.341 5.351 5.352A 5.354
1 530-1 535 SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A Earth exploration-satellite Fixed Mobile except aeronautical mobile 5.341 5.342 5.351 5.354	**1 530-1 535** SPACE OPERATION (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A Earth exploration-satellite Fixed Mobile 5.343 5.341 5.351 5.354	
1 535-1 559	MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.341 5.351 5.353A 5.354 5.355 5.356 5.357 5.357A 5.359 5.362A	
1 559-1 610	AERONAUTICAL RADIONAVIGATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.208B 5.328B 5.329A 5.341 5.362B 5.362C	

- UK Allocations (L-band) as an example



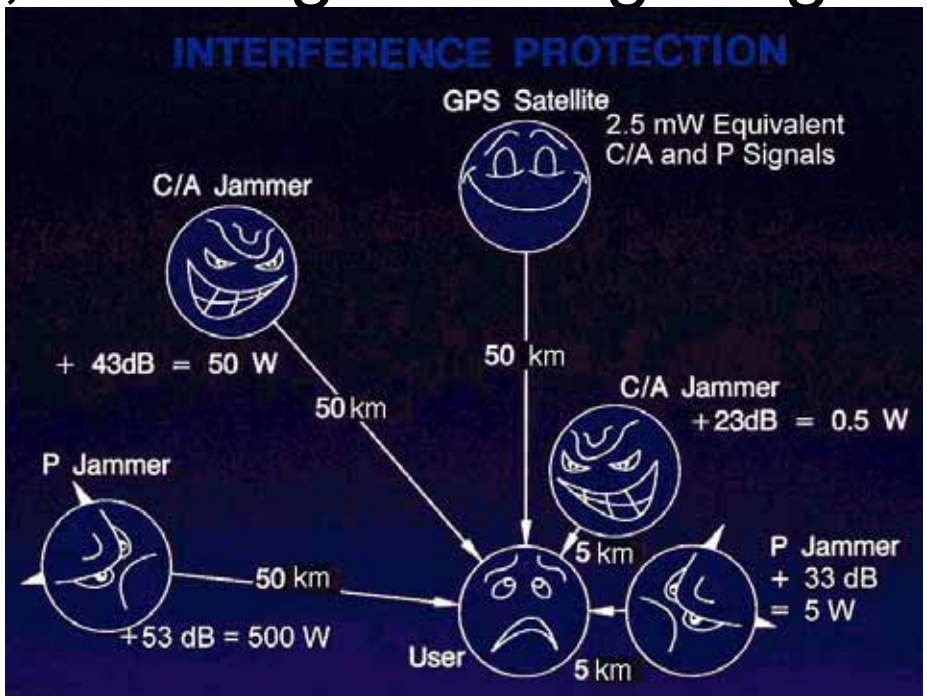
Interference and Spectrum Management (3 of 3)

Spectrum Management at National Level

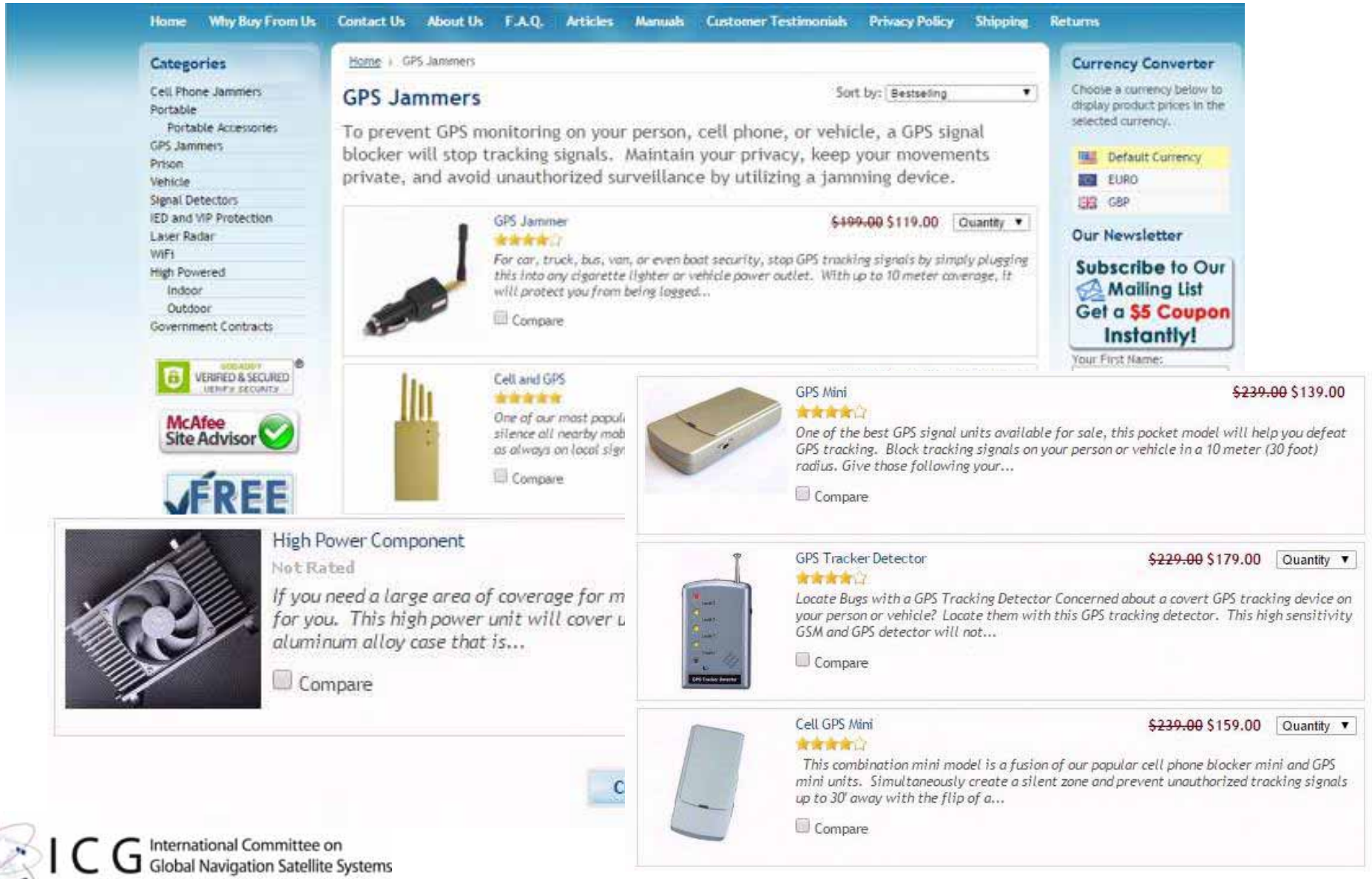
- National Spectrum Agencies' activities were introduced with their role to maintain/improve the safety and reliability of radio use.
- Differences in spectrum allocation and protection among different National Spectrum Agencies were also illustrated. In particular, different regulations/guidelines (e.g., allowable emission levels) for non-radio service emissions such as ISM (e.g., escalators) emissions and Short Range Device (e.g., UWB) emissions exist among different National Spectrum Agencies.

Possible Danger at Present (1 of 3)
GNSS Jammer

- GNSS Jammers are a radio frequency transmitters that intentionally prevent GNSS receivers from acquiring, tracking or navigating with GNSS signals.
- GNSS Jammers are used by thrill seekers, privacy protectors, criminals and terrorists etc.
- Spoofing, which is to fool GNSS receivers with false PNT information is also problem.

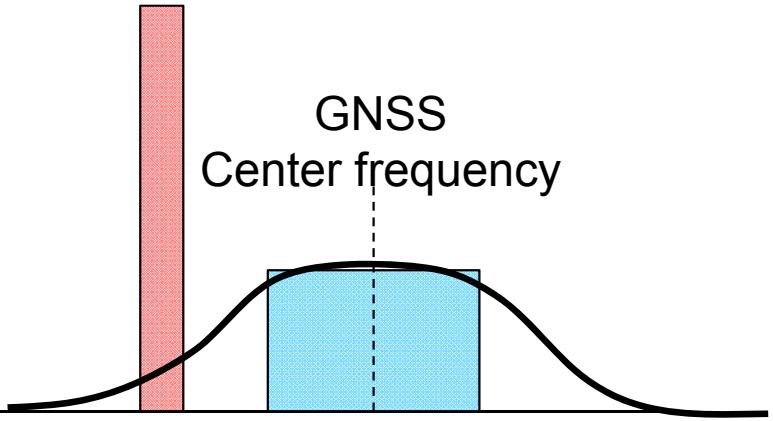


Possible Danger at Present (2 of 3)
GNSS Jammer Examples



Possible Danger at Present (3 of 3)
Adjacent Band Interference Concerns

- Applicable in cases when high powered service, for example, terrestrial, is planned adjacent to GNSS bands.
- Potential for 1) front-end compression and 2) undesired responses created by mixing an out-of-band signal with a GNSS local oscillator
- Front-end filtering can help reduce this effect but high power adjacent band sources will still be problematic



Spectrum Protection Activities in ICG

- ICG provides a forum that can facilitate and encourage the protection of GNSS spectrum
- Topics discussed at ICG:
  - Electromagnetic Emissions
  - Interference Detection and Geo-Location Capabilities (challenge of detecting weak interferers, such as GNSS jammers, because those interfering levels are week but still stronger to impact on GNSS reception)
  - Critical Infrastructure

ICG Expert Meeting Materials

- The materials of ICG Expert Meetings can be found in the following web-site:

http://www.unoosa.org/oosa/en/ourwork/icg/activities/2015/icg-experts-meeting_presentations.html