EMERGENCY WARNING SERVICES
via GNSS signals

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Yasuhiko Kawazu, National Space Policy Secretariat

12th Meeting of the International Committee on Global Navigation Satellite Systems
Emergency Warning Service Background

- **Global trend to develop Disaster Risk Reduction technologies**
  - *Sendai Framework for Disaster Risk Reduction 2015-2030 endorsed by the UN General assembly*
  - *Asian Ministerial Conferences on Disaster Risk Reduction (AMCDRR)*
  - *European Forum for Disaster Risk Reduction (EFDRR)*
  - *National initiatives*

- **Need to develop Disaster Risk Reduction technologies**
  - *Japan Cabinet Office, National Space Policy Secretariat*
  - **QZSS Satellite Report for Disaster and Crisis Management DC Report service**
  - *European Commission:*
    - **Studying a new potential Galileo based EWS service**
EU Member States were contacted (civil protection).
Non EU countries
Face to face meetings, online questionnaires, teleconferences
A GNSS-based Emergency Warning System is a significant improvement for EWS-lacking countries and countries already owing an EWS:

- Resilience to ground destruction and reliability
- Global: Standardisation
- Multi-hazard (tornadoes, earthquakes, nuclear disaster or industrial disaster, terrorist attacks)
- Independent of any terrestrial infrastructure/communication channel
- Additional channel on top of existing EWS and Possible combination with other alerting means (sirens...) or telecommunication channels

=>>MAJOR BENEFITS !!
Taking the opportunity of the coverage area provided by navigation satellites:

- Global coverage for the Galileo constellation
- Asian zone for the QZSS constellation

**Coverage Area of QZSS**
The figure shows areas where at least one QZS is visible, with lines representing the elevation angles.

**QZSS and Galileo common objective:** aiming at deploying Emergency Warning Services through the navigation signals
QZSS DC-Report service

DC Report is the service which Disaster Prevention Information (Earthquake, Tsunami, etc.) and crisis management are delivered. Supply sources of information are JMA (Japan Meteorological Agency) and the other organizations.

The trial service of DC Report has been started from 27th September!
Emergency Warning Service

★ Use case of DC-Report service

Digital Signage Applications

Example of display message:
- Earthquake Early Warning
  Pay alert for strong earthquake.
- Earthquake in Pacific coast
  Maximum seismic intensity is 5 upper.

Vending Machine

Confirm DC Report message
Free provide of drinks
Disaster countermeasure Vending Machine

Car Navigation System

Confirm DC Report message

Control Unit

(L1S-compatible receiver)

Warning
Earthquake occurred

QZSS

DC Report

( L1S-compatible terminal )
Use case of DC-Report service

**Tsunami Warnings**

- **Signs with voice guidance (broadcast disaster information)**
  - Provide disaster information and guide to evacuation area by voice guidance and electronic board.
  - Install on area map or electric poles or any other necessary places.

- **Providing disaster information in cooperation with QZSS.**
  - L1S-compatible receiver inside
  - Display disaster information or guide by speaker.

- Display evacuation information or guide by speaker.
Limited use of Navigation data broadcast capacity

- DC-Report and SLAS (Sub-meter Level Augmentation Service) signal broadcast pattern is fixed.
- When DC-Report has not any information, NULL Message is broadcasted at DC-Report broadcast timing.
- SLAS message and DC-Report message are no influence each other.
- SLAS positioning service and DC-Report service are consist of independence, and these services can be used simultaneously.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Service Name</th>
<th>Center freq.</th>
<th>Modulation</th>
<th>Bit Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1S</td>
<td>Sub-meter Level Augmentation Service (SLAS)</td>
<td>1575.42MHz</td>
<td>BPSK</td>
<td>250bps</td>
</tr>
<tr>
<td></td>
<td>DC Report Service</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Consistent with:

"ITU EWS type messages can be covered under Radio Regulation Article 4.4, which allows non-allocated transmissions (such as basic messaging) provided they do not impact the allocated radio services (navigation). "

"
SLAS evaluation result
Influence of the ionosphere in Okinawa

Comparison of L1C/A and SLAS

Comparison of position estimating in 16:00

<table>
<thead>
<tr>
<th></th>
<th>Avg.</th>
<th>1σ</th>
<th>2σ</th>
<th>95%</th>
<th>unit [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 C/A</td>
<td>11.97</td>
<td>12.56</td>
<td>13.15</td>
<td>12.7</td>
<td></td>
</tr>
<tr>
<td>L1+L2</td>
<td>1.64</td>
<td>2.48</td>
<td>3.32</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>SLAS</td>
<td>0.54</td>
<td>0.96</td>
<td>1.37</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>

Ionospheric TEC MAP

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SLAS: Sub-meter
10:00 JST
14:00 JST
15:00 JST
16:00 JST

Okinawa

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Currently studying the possibility of EWS through the following Galileo signals

- **Some data broadcast capacity currently available on**
  - **E1B**: One word, 128 bits available
  - **E5B**: More bandwidth available
- **Next generation of Galileo satellites (G2G)**

Ideally, targeting mobile phone (E1B, E5 is coming!)
EWS: To make it work globally: A common effort

- EWS providers
  - Technical level
    - Converge on EWS data formats and standards
    - Development of an operational EWS network and/or operational interfaces (Civil protection / GNSS Operations)

- Receiver industry needs to be involved

- Policy level:
  - GNSS program managers (Cabinet Office NSPS, European Commission, ...)
  - Japan/EU open to working multilaterally to develop [a common approach/a common message /commonalities / synergies with other systems]
THANK YOU

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Emergency Warning Services (back-up slide)

★ SLAS Positioning Accuracy
  ➢ SLAS is kept high accuracy even including DC-Report (or NULL) message broadcast.

<table>
<thead>
<tr>
<th>monitoring station</th>
<th>evaluation point</th>
<th>Baseline length [km]</th>
<th>Positioning Accuracy [m] (95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Horizontal</td>
</tr>
<tr>
<td>Sapporo</td>
<td>Fujisato</td>
<td>343</td>
<td>0.83</td>
</tr>
<tr>
<td>Sendai</td>
<td>Kamitakara</td>
<td>420</td>
<td>0.68</td>
</tr>
<tr>
<td>Hitachi-ohta</td>
<td>Sakashita</td>
<td>280</td>
<td>0.85</td>
</tr>
<tr>
<td>Komatsu</td>
<td>Shioya</td>
<td>314</td>
<td>0.90</td>
</tr>
<tr>
<td>Kobe</td>
<td>Ohzu</td>
<td>296</td>
<td>0.73</td>
</tr>
<tr>
<td>Hiroshima</td>
<td>Uji</td>
<td>310</td>
<td>0.85</td>
</tr>
<tr>
<td>Fukuoka</td>
<td>Ohda</td>
<td>278</td>
<td>0.74</td>
</tr>
<tr>
<td>Tanegashima</td>
<td>Kushima2</td>
<td>90</td>
<td>0.75</td>
</tr>
<tr>
<td>Amami</td>
<td>Wadomari</td>
<td>70</td>
<td>0.84</td>
</tr>
<tr>
<td>Itoman</td>
<td>Izena</td>
<td>95</td>
<td>0.78</td>
</tr>
<tr>
<td>Miyako-jima</td>
<td>Irabu</td>
<td>65</td>
<td>0.72</td>
</tr>
<tr>
<td>Ishigaki-jima</td>
<td>Tarama</td>
<td>60</td>
<td>0.75</td>
</tr>
<tr>
<td>Chichi-jima</td>
<td>Haha-jima</td>
<td>50</td>
<td>0.87</td>
</tr>
</tbody>
</table>
SLAS evaluation result
Influence of the ionosphere in Okinawa

• Influence of ionosphere in Okinawa
  - Okinawa is located low magnetic latitude, so this area is big influence from ionospheric disturbance.

• Comparison of L1 C/A and SLAS
  - L1 C/A positioning had been degrade at afternoon caused by ionosphere, but SLAS could be provided stable positioning service at any time.
  - SLAS can be provided positioning accuracy around 1m.

• Comparison of position estimating at 16:00
  - This graph and table shows comparison between L1 C/A only positioning, Dual frequency (L1C/L2C) positioning and SLAS positioning at 16:00.