High Precision Navigation Capabilities (L1-SAIF) and Applications Using Japanese Quasi-Zenith Satellite System (QZSS)

ICG WG-B Application SG Meeting
Munich, Germany
March 12, 2012

Satellite Positioning Research and Application Center (SPAC)
Functions of QZSS

- Increasing Coverage & Availability

- Enhance GPS Performance

“QZSS and MSAS”, ICG-6, Tokyo, 2011
Secretariat of Strategic Headquarters for Space Policy
Functions of QZSS

- QZSS Satellite Overview

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>Around 4ton</td>
</tr>
<tr>
<td>Power</td>
<td>Around 5kw</td>
</tr>
<tr>
<td>Design Life</td>
<td>10 years</td>
</tr>
<tr>
<td>Launch Date</td>
<td>September 11, 2010</td>
</tr>
</tbody>
</table>

L1-SAIF Antenna

L-band Antenna
## Functions of QZSS

### QZSS Navigation Signals

<table>
<thead>
<tr>
<th>Signal</th>
<th>Channel</th>
<th>Frequency</th>
<th>Interoperability</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1C</td>
<td>L1CD</td>
<td>1575.42 MHz</td>
<td>GPS-like supplemental signals with minimum modifications from GPS signals</td>
</tr>
<tr>
<td></td>
<td>L1CP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1-C/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2C</td>
<td></td>
<td>1227.6 MHz</td>
<td></td>
</tr>
<tr>
<td>L5</td>
<td>L5I</td>
<td>1176.45 MHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L5Q</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1-SAIF</td>
<td></td>
<td>1575.42 MHz</td>
<td>SBAS-like augmentation signal (250bps)</td>
</tr>
<tr>
<td>LEX</td>
<td></td>
<td>1278.75 MHz</td>
<td>QZSS-specific augmentation signal (2kbps)</td>
</tr>
</tbody>
</table>

©JAXA IS-QZSS(Interface Specification for QZSS)
QZSS L1-SAIF Signal

- **L1-SAIF** (Submeter-class Augmentation with Integrity Function)
  - Development: by ENRI
  - Utilization and Demonstrated: by SPAC

- **Functions**
  - Ranging
  - Error Correction
    - Wide-area differential correction
    - Target accuracy: 1m (horizontal)
  - Integrity

- **Interoperability and compatibility**
  - Interoperable with GPS L1C/A
  - Fully compatible with SBAS
  - Additional messages are included in L1-SAIF signal
QZSS L1-SAIF Signal

Structure of L1-SAIF system

- Collect GEONET data
- L1-SAIF Signal Generation
- Augmentation Information
  - Clock Correction
  - Orbit Correction
  - Ionospheric Correction
- Information to accelerate TTFF
- GEONET
  GPS Earth Observation Network System
  1200 points

QZSS

GPS
## QZSS L1-SAIF Signal

### Structure of L1-SAIF message

<table>
<thead>
<tr>
<th>Preamble</th>
<th>Message Type</th>
<th>Data Field</th>
<th>CRC Parity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 bits</td>
<td>6 bits</td>
<td>212 bits</td>
<td>24 bits</td>
</tr>
</tbody>
</table>

1 message = 250 bits broadcast every second

### L1-SAIF Message

- **SBAS compatible message**
  - Type ID: 0-7, 10, 18, 24-26, 28, 62-63

- **SBAS non compatible message**
  - Type ID: 52-60

- **QZSS unique message (for civil utilization demonstration)**
  - Type ID: 40-51
# Structure of L1-SAIF message

<table>
<thead>
<tr>
<th>Message Type</th>
<th>Contents</th>
<th>Used by</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 to 51</td>
<td>Undefined (QZSS)</td>
<td>—</td>
<td>— (L1-SAIF)</td>
</tr>
<tr>
<td>52</td>
<td>TGP mask</td>
<td>L1-SAIF</td>
<td>Tentative</td>
</tr>
<tr>
<td>53</td>
<td>Tropospheric delay</td>
<td>L1-SAIF</td>
<td>Tentative</td>
</tr>
<tr>
<td>54 to 55</td>
<td>Advanced Ionospheric delay</td>
<td>L1-SAIF</td>
<td>TBD</td>
</tr>
<tr>
<td>56</td>
<td>Intersignal biases</td>
<td>L1-SAIF</td>
<td>Tentative</td>
</tr>
<tr>
<td>57</td>
<td>Ephemeris-related parameter</td>
<td>L1-SAIF</td>
<td>TBD</td>
</tr>
<tr>
<td>58</td>
<td>QZS ephemeris</td>
<td>L1-SAIF</td>
<td>Tentative</td>
</tr>
<tr>
<td>59</td>
<td>QZS almanac</td>
<td>L1-SAIF</td>
<td>TBD</td>
</tr>
<tr>
<td>60</td>
<td>Regional information</td>
<td>L1-SAIF</td>
<td>TBD</td>
</tr>
</tbody>
</table>

“Ranging Quality of QZSS L1-SAIF Signal”, IONITM 2012, Newport Beach, 2012
Electronic Navigation Research Institute
Demonstration of L1-SAIF Capability

- Following 14 points have been selected from GEONET to generate L1-SAIF augmentation information
- L1-SAIF capability has been evaluated

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical (GPS only)</td>
<td>1.83 (m)</td>
</tr>
<tr>
<td>Horizontal (GPS only)</td>
<td>1.30 (m)</td>
</tr>
<tr>
<td>Vertical (GPS+L1-SAIF)</td>
<td>0.59 (m)</td>
</tr>
<tr>
<td>Horizontal (GPS+L1-SAIF)</td>
<td>0.38 (m)</td>
</tr>
</tbody>
</table>

“Activities for QZS application demonstration in private sector”, SPAC Symposium 2011, Tokyo, 2011, SPAC
Demonstration of L1-SAIF Capability

Effects of L1-SAIF (1/2)

GPS only: Horizontal Error (RMS)

7. Ogasawara Islands →

14. Okinawa Islands →

“Activities for QZS application demonstration in private sector”, SPAC Symposium 2011, Tokyo, 2011, SPAC
Overview of L1-SAIF Capability

- Effects of L1-SAIF (2/2)

L1-SAIF: Horizontal Error (RMS)

“Activities for QZS application demonstration in private sector”, SPAC Symposium 2011, Tokyo, 2011, SPAC
L1-SAIF Application Fields

- **Major L1-SAIF Application Fields**

  - **On-Board Unit**
  - **Personal Use**
  - **Disaster Prevention**
  - **Life Support**
  - **ITS (Intelligent Transport System)**

“Activities for QZS application demonstration in private sector”, SPAC Symposium 2011, Tokyo, 2011, SPAC
L1-SAlF Application Fields

- Application for ITS
  - Enhancement of GPS navigation results has been confirmed by the demonstration.
  - By using L1-SAlF signal, cruising lane of each car can be identified.

Date: 2011.10.17 & 2011.11.17
Place: Nagoya-city
Remark: 7 times round trip data are superimposed

“Activities for QZS application demonstration: ITS”, SPAC Symposium 2011, Tokyo, 2011, Aisan Technology Company LTD.
L1-SAIF Application Fields

- Application for Personal Use
  - “Sekai Camera” is new AR application to provide millions of Air Tags (by Tonchidot Corporation)
  - L1-SAIF provides capability to show Air Tags at the precise position to each place.

Examples of Air Tags

“The world of SekaiCamera”, 9th Satellite Positioning and Geospatial Information Form 2011, Tokyo, 2011, Tonchidot Corporation
L1-SAIF Application Fields

- AR application
  - AR : Augmented Reality
    Technology to display additional information to the real world by using computer assist

- Based on geographical information obtained from L1-SAIF signal, it is possible to provide facility information around the area and recommended route information by overlaying these digital information on the reality space in Map and Camera Screens.

L1-SAIF Application Fields

- Application for Disaster management (Earth Quake)
  - Horizontal and vertical displacement due to coseismal slip can be detected by GPS.
  - Following figure shows GPS observation by the Geospatial Information Authority of Japan. By using L1-SAIF signals, the movement can be detected more accurately.

“Tsunami Impacting Eastern Japan and Preparedness for Extraordinary Natural Disaster”,
Port and Airport Research Institute, Japan
L1-SAIF Application Fields

- Application for Disaster management (Tsunami)
  
  - Tsunami height was measured with GPS buoy as shown below.
  - By using L1-SAIF signals, the movement can be detected more accurately

“Tsunami Impacting Eastern Japan and Preparedness for Extraordinary Natural Disaster”,
Port and Airport Research Institute, Japan
Summary

- “Augmentation” is characteristic feature of the QZSS.
- Demonstration of L1-SAIF signal has been conducted by SPAC and improvement by L1-SAIF augmentation has been confirmed.
- Signal characteristics of L1-SAIF has been already issued by IS-QZSS http://qzss.jaxa.jp/is-qzss/index.html
  IS-QZSS : Interface Specifications for QZSS
- L1-SAIF provides efficient augmentation information for “High Precision Navigation Market”