Position location at Qualcomm
Pre-GPS to SoC
Irwin Mark Jacobs, Founding Chairman and CEO Emeritus
November 2, 2016
OmniTRACS, First Commercial Product
Two-way data communications and position location

Transition from LORAN to Qualcomm 2-Satellite Positioning

Commercial launch with Schneider National, October 1988
Next, Development of CDMA for 2G Cellular

Started following the commercial launch of OmniTRACS, November 1988

**November 1989**
First CDMA demonstration in San Diego; then Manhattan

**November 1991**
CDMA commercial size phone demonstrated - 3 custom chips

**July 1993**
IS-95 2G cellular CDMA standard issued

**November 1995**
First commercial 2G CDMA network launched in Hong Kong

To reduce cost, GPS is used to time and frequency synchronize CDMA

1989 demo system
Van-size “mobile” phone with 2 base stations
Challenge: Incorporate GPS in CDMA to Meet E911 Requirements

Significant Problems with enabling GPS in mobile

- Poor Antenna for GPS
- Self-jamming (FDD)
- Low level signal
- Rapid response
- High accuracy
- Low power
- Affordable components
- Space constrained
SnapTrack acquired in 2000

Assisted-GPS (A-GPS) incorporated in CDMA mobile in one year; later standardized in 3GPP / 3GPP2

Early E911 prototyping performance studies, 1998
Competition with Advanced Forward Link Trilateration (AFLT)

E911 Phase 2 specified <50 meters 67% of the time for 95% phones by 12/31/2005
Today, ~170 million E911 Calls Annually with A-GPS successfully meeting E911 requirements
### Mobile SoC evolves with Growing GNSS

**Operate with up to 85 satellites by end of 2016**

<table>
<thead>
<tr>
<th>Year</th>
<th>GNSS</th>
<th>Satellites/Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>GPS</td>
<td>United States 31 satellites</td>
</tr>
<tr>
<td>2011</td>
<td>Glonass</td>
<td>Russia 24 satellites</td>
</tr>
<tr>
<td>2014</td>
<td>BeiDou</td>
<td>China 14 satellites (35 total)</td>
</tr>
<tr>
<td>2016</td>
<td>Galileo, QZSS</td>
<td>Europe and Japan 2nd Half 2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Correlator capacity</th>
<th>Power</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>~10K</td>
<td>100’s mA</td>
<td>On demand single fix</td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Correlator capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>~1M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>&gt;15 dB sensitivity improvement</td>
<td>Few mA’s</td>
<td>Ubiquitous always on</td>
</tr>
</tbody>
</table>
Location in Qualcomm’s integrated mobile platform

- Many location based apps running on high performance AP/GPU
- Low power signal processing
- Shared memory
- Correlator engine for rapid acquisition of weak signals
- Integrated RF
- Use all GNSS constellations + bands
- Cloud services enable A-GNSS for E911/LBS
- MEMS sensor assisted positioning
- Barometer
- WLAN RSSI + RTT
- WWAN ranging
- Co-existence management
- Spoof detection + mitigation
Mobile GPS - from saving lives to providing the foundation for innovative new uses

- Watches
- Fitness Bands
- Drones
- ATMS
- Bulldozers
- Stoplights
- Weather Forecasting
- Automotive
beyond navigation
Opening new opportunities with high precision positioning

Connected car and autonomous driving
• Road-level to lane-level guidance
• Autonomous driving <<1m accuracy
• Very low Latency communications

Drones and robotics
• Search and rescue
• Safety in geo-hazard environments
• Weather monitoring
• Precision agriculture
A growing set of drone use cases

All Require Accurate Position Location

**Flying cameras**
- Consumer flying cameras
- Movies and news media
- Real estate

**Delivery**
- Package delivery
- Transport of medicines and vaccines

**Public safety**
- Emergency services
- Cellular coverage for first responders
- Search and rescue

**Agricultural**
- Crop visual inspections
- Automated planting
- Livestock tracking

**Inspection**
- Critical infrastructure inspection (e.g. cell towers, bridges)
- Inspection of hard-to-reach assets (e.g. oil & gas, wind turbines)
Enabled by Progress Fusing Visual-inertial odometry with GPS/GNSS for accurate localization

- Accurate 6-Degrees Of Freedom pose

![Diagram](image.png)
Challenges remain for a complete mobile location experience

- Lack of location ubiquity deep indoors
- Vertical Accuracy
- Battery drain
- Privacy management
- Rapid Fusion with Multiple Sensors and Data from Cloud
Thank You

Snapdragon is a trademark of QUALCOMM Incorporated, registered in the United States and other countries. Qualcomm Halo and Toq are a trademark of QUALCOMM Incorporated.