GNSS, 5G-based PNT, and their fusion

Florin-Catalin Grec

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Topics

01. PNT landscape in 5G: specifications vs real-life products

02. R&D GNSS + 5G at ESA

03. 5G PNT Operational Services
5G

5G is the latest iteration of cellular technology, engineered to greatly increase the speed and responsiveness of wireless networks. It is a new global wireless standard after 1G, 2G, 3G, and 4G network.

5G standards roadmap

Different PNT performance targets in 5G compared to past generations!
3GPP

- 3GPP is a collaborative, engineering organization that develops technical specifications for cellular systems which then are transposed into standards by the regional Standards organizations such as e.g. ETSI. https://www.3gpp.org/.

- Working principle: new features are introduced into the cellular system by 3GPP via Releases (currently Release 17). Each release is self-contained, meaning that one can build a cellular system based on the set of specifications in that release. To produce specifications, 3GPP members submit technical documents, often referred to as contributions, to propose solutions and technologies as part of projects called “Work Items”. These contributions are discussed publicly in 3GPP meetings (time permitting) and agreed on.

- Since early 2017, ESA’s 5G PNT Navigation Task Force, under European Commission delegation through the H2020 Framework Programme for Research and Innovation in Satellite Navigation (HSNAV), contributes to 3GPP works on PNT and promotes the inclusion of EGNSS into 5G PNT services.
5G radio advancements for accurate PNT

#1 New Spectrum
Frequency Range 1: up to 7.125 GHz
Frequency Range 2: up to 24.25 – 52.6 GHz

#2 Massive MIMO

#3 Positioning Signals

#4 Non 3GPP technologies

#5 Ultra dense deployment
5G Positioning Techniques and Measurements

New PNT features brought by Release 16 of 3GPP:

Prior to release 16, location of mobile devices with cellular signals could operate only in the network-assisted mode: users performs measurements, network computes the location.

Release 16 brings user-based cellular positioning. This has the potential of unlocking the full potential of GNSS + 5G.

Performance targets (not committed requirements) by release:

- Release 16: 3m and 10m for indoor and outdoor use cases (80%)
- Release 17: indoor positioning functionality <1m (80%) accuracy for IIoT
5G meets GNSS: transmission of high accuracy corrections

<table>
<thead>
<tr>
<th></th>
<th>OSR</th>
<th>SSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release 15 (2018)</td>
<td>RTK, N-RTK</td>
<td>PPP</td>
</tr>
<tr>
<td>Release 16 (2020)</td>
<td>-</td>
<td>PPP-RTK</td>
</tr>
</tbody>
</table>

Note, A-GNSS (for fast time to first fix and battery preservation) exists in LTE Positioning Protocol since Release 9. GNSS assistance data needed for OSR and SSR methods were added as extensions to A-GNSS packet.
Hybrid GNSS - 5G: first results based on field measurements

- The first ever GNSS – 5G concurrent field campaign was funded by ESA’s EGEP programme and as part of GINTO5G project.
- Three areas: indoor, open sky, outdoor with obstacles
- What data has been collected?
  - Multi-frequency GPS, Galileo, GLONASS (code and phase)
  - Pseudorange 5G 3.7 – 3.8 GHz

[Image of field test measurement setup]

- [https://www.ion.org/publications/abstract.cfm?articleID=17609](https://www.ion.org/publications/abstract.cfm?articleID=17609)
Hybrid GNSS - 5G: first results based on field measurements

- Post-processed results

- Positioning approach: fusion of pseudo-ranges i.e. GNSS code-based (L1/E1 only) and 5G pseudoranges

<table>
<thead>
<tr>
<th>Outdoor urban Test</th>
<th>GNSS Single Frequency Code-based 2D @95%</th>
<th>5G 2D @95%</th>
<th>GNSS SF + 5G 2D @95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>2.6 m</td>
<td>1.33 m</td>
<td>2.2 m</td>
</tr>
<tr>
<td>#2</td>
<td>2.25 m</td>
<td>1.9 m</td>
<td>2.36 m</td>
</tr>
<tr>
<td>#3</td>
<td>1.42 m</td>
<td>0.96 m</td>
<td>1.3 m</td>
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</tbody>
</table>

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<thead>
<tr>
<th>Outdoor – Indoor transition</th>
<th>GNSS SF code-based 2D @95%</th>
<th>5G 2D @95%</th>
<th>GNSS + 5G 2D @95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>20.44 m</td>
<td>31.75 m</td>
<td>21.91 m</td>
</tr>
<tr>
<td>#2</td>
<td>36.24 m</td>
<td>36.71 m</td>
<td>35.19 m</td>
</tr>
</tbody>
</table>

- 5G-based PNT is not a killer of GNSS. It can complement GNSS and address indoor areas.
4G/5G PNT operational services

GNSS RTK (NTT Docomo, Japanese telecom operator)

SoftBank Corp.'s proprietary GNSS receiver has an embedded GNSS antenna to receive signals from QZSS satellites, including Michibiki, as well as other Japanese and international satellites.
https://www.softbank.jp/en/sbnews/entry/20210825_01
Conclusions

- To our knowledge, today’s 5G network match Release 15 features meaning that no 5G-based positioning operates on existing 5G public networks;
- Through the features specified in Release 16, 5G has the potential to act as PNT system not just as opportunistic navigation system;
- However, optimizing deployments in outdoor for positioning are very expensive → 5G-based accurate positioning is expected to take off in controllable environments such as private networks;
- GNSS is expected to continue being the primary positioning technology for outdoor areas. It can benefit from hybridization with 5G techniques especially when transitioning from outdoor to indoor, and deep urban.

<table>
<thead>
<tr>
<th>Outdoor</th>
<th>Transition Indoor-Outdoor / Deep Urban</th>
<th>Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNSS</td>
<td></td>
<td>Bluetooth</td>
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<tr>
<td>High Accuracy GNSS</td>
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<td>WiFi</td>
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<tr>
<td>5G DL-TDoA</td>
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<td>5G UWB</td>
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Thank you for attention!

florin-catalin.grec@esa.int