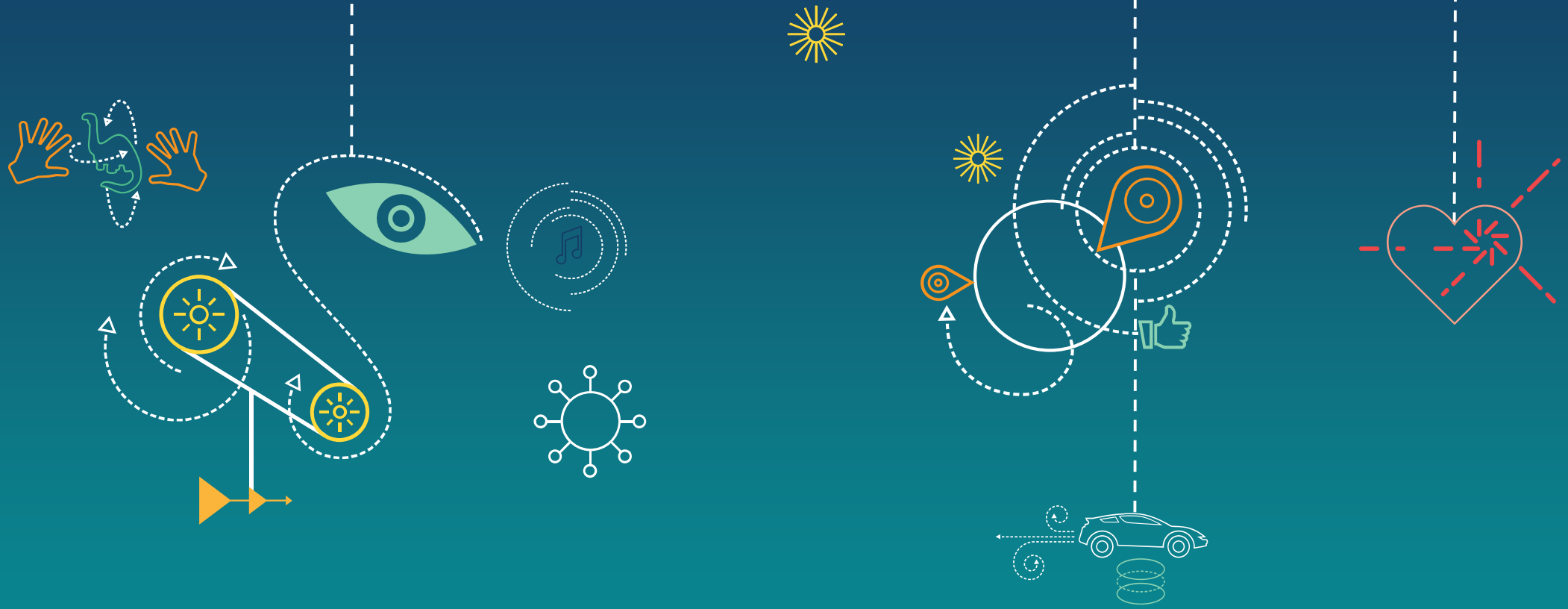

QUALCOMM®

Douglas Rowitch, Sr. Director, Technology
Qualcomm, Inc., April 26, 2013

ICG Interoperability Workshop

Acknowledgement

Thank you for the invitation!

- Qualcomm would like to thank the ICG for the opportunity to participate in this Interoperability Workshop

- GNSS has proven to be a key technology in Qualcomm's product offerings

- We look forward to the use of modern GNSS signals in the future and appreciate the opportunity to contribute feedback that can be considered when making decisions about future signals

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QUALCOMM®

Fortune 500 Company

25+ years of driving the evolution of wireless

Making wireless more personal, affordable and accessible to people everywhere

World's largest fabless semiconductor company, #1 in wireless

Driving differentiation with industry's leading Location platform

Integrated and discrete solutions for smartphones, tablets, notebooks, CE

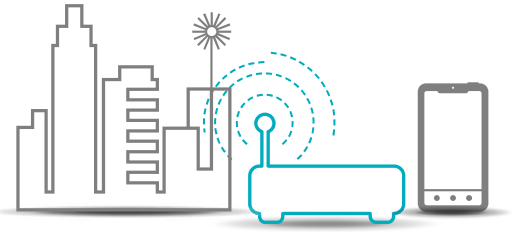
Satellite-Based GNSS Solutions

First commercial GPS in a cell phone in 2000
Over 1 Billion devices shipped to date
Designed in with 40+ OEMs/ODMs
Deployed at hundreds of mobile operators
First to cellular market with GPS+GLONASS

Augmentation Technologies

(Cellular, Wi-Fi, Sensors, Servers)

Enhancing accuracy – everywhere



Indoor Location Solutions

Most Precise Indoor (<5m)

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Current Qualcomm GNSS Capabilities

GNSS is an essential component in the Qualcomm IZat location solution

- Qualcomm GNSS enabled chipsets support
  - GPS L1 C/A + GLONASS L1
- Multi-GNSS positioning offers improved position accuracy and availability in GNSS denied environments
  - Urban Canyon
  - Forested
  - Some Indoor Scenarios
- Location based and emergency services rely heavily on GNSS signals
- Qualcomm GNSS solutions target
  - High sensitivity
  - High location availability
  - Medium precision

Multi-GNSS

Existing GNSS signals

- Qualcomm considers all Open Service (OS) GNSS signals for use in its products
- Some practical considerations may limit or delay commercial use of these signals in high volume mobile wireless devices
  - Availability of new signals at Fully Operational Capability (FOC)
  - Interoperability/Compatibility of new signals
- As satellite signals meet such criteria for large scale commercial use and provide benefit to our customers, Qualcomm will strongly support adoption in its products

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Interoperability and Compatibility

Modern GNSS signals

- The GNSS solution in a wireless mobile device is often subject to constraints
  - Size – limited space for antennas (dual frequency receivers can be a challenge)
  - Cost – support for multiple frequencies can add to device cost
  - Power – support for multiple frequencies or wider bandwidths may increase power consumption
- Qualcomm has a preference for multi-GNSS signals at common carrier frequencies with common spectral bandwidths
- Qualcomm is excited at the prospect of leveraging satellite positioning signals from four global constellations, as well as, other regional constellations and encourages the ICG members to continue to pursue interoperable and compatible GNSS signals for the future.

GNSS Interference

GNSS robustness to interference is an additional concern for Qualcomm

- GNSS Cross-Correlation
  - We believe it is important to cooperatively co-design signals across GNSS constellations to mitigate cross-correlation interference
- Other Interference
  - Self Interference – with many high power wireless radio transceivers packed into wireless mobile devices, GNSS receivers are susceptible to self interference.
  - External Interference – intentional and unintentional jamming in GNSS bands is always a concern

- More robustness to jammers in future GNSS signal design is strongly urged

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Conclusion

Thank you!

- Once again, Qualcomm would like to thank the ICG for the opportunity to participate in this Interoperability Workshop
- GNSS is and will continue to be a key technology in Qualcomm's product offerings
- We look forward to the use of modern GNSS signals in the future and appreciate the opportunity to contribute feedback that can be considered when making decisions about future signals

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Qualcomm Interoperability Survey Response (1/5)

Slide No.	Question	Answer
7	What types of applications do your receivers (or receiver designs) support?	[QCOM] Broad range of positioning applications hosted on smart phones, feature phones, laptops, tablets, wireless modules, telematics, M2M and other types of wireless mobile devices, based on open GNSS signals. Qualcomm GNSS solutions target very high sensitivity, high availability and medium precision. Qualcomm has shipped more that 1 billion cumulative GPS/GNSS enabled chipsets since 2000.
8	Do you see a threat to GNSS receivers due to many more GNSS signals centered at 1575.42 MHz?	[QCOM] We believe it is important to co-design interoperable signals from different GNSS constellations to maximize compatibility. However, this threat is perceived to be minor in QCOM products relative to the problem of self interference caused by high power wireless radio transmissions out of GNSS bands, not to mention in-band external jammers. More robust (jammer resistant) signal designs in GNSS will serve to mitigate wireless transmitter interference as well as enhance GNSS compatibility.
8	Whether you see a threat or not, do you prefer all new CDMA signals at "L1" to be centered at 1575.42 MHz or have some of them elsewhere, e.g., at 1602 MHz?	[QCOM] Qualcomm pursues a flexible approach to frequency management and is open to discussion on other frequency plans if there is real performance benefit. That said, Qualcomm's soft preference is for new signals to be centered at 1575.42 MHz".

Qualcomm Interoperability Survey Response (2/5)

Slide No.	Question	Answer
8	Given that most GNSS providers plan to transmit a "modernized" signal at 1575.42 MHz, what is your long term perspective on whether you will continue to use C/A? Why? How?	[QCOM] Once the L1C modern signal is transmitted by all operational space vehicles, we see no need to support L1 C/A, assuming L1C can be acquired as rapidly as L1 C/A with comparable resources.
9	Once there are a large number of good CDMA signals, will there be continuing commercial interest in FDMA signals? Why or Why Not?	[QCOM] We see little interest in FDMA signals once there are a sufficient number of CDMA signals at a common frequency.
10	Do you prefer signals in different "L1" frequency bands for interference mitigation rather than at one center frequency for interoperability? Why?	[QCOM] We prefer interoperable, co-designed signals at a common frequency. This enables lower cost, power, area implementations in consumer wireless mobile devices.
11	If a satellite's signals do not meet quality standards, what should happen (see list in slide)?	[QCOM] We do not want to see such satellites transmit non-standard codes, as such signals might represent problematic cross-correlation sources. Of the remaining options, we believe they should (a) be set to unhealthy and (b) stop transmitting.
11	To assure only "good" signals, should GNSS providers agree on minimum international signal quality standards and agree to provide only signals meeting the standard?	[QCOM] Yes.
12	Given that L5/E5a will be transmitted by most GNSS providers, do you intend to use the E5b signal? If so, for what purpose?	[QCOM] Qualcomm cannot comment on forward looking product features, capabilities, or implementation details.

Qualcomm Interoperability Survey Response (3/5)

Slide No.	Question	Answer
13	For your applications, are small satellite “frequency steps” a problem?	[QCOM] Qualcomm GNSS receivers must cope with local oscillator dynamics and mobile motion which are likely much larger than the types of frequency steps seen in satellite transmitters. As such, this issue is not a concern for Qualcomm.
13	If so, what interval between “frequency steps” and what delta-f magnitude would be excessive?	
14	Assuming signal quality is acceptable from every provider, would you limit the number of signals used by provider or by other criteria? What criteria?	[QCOM] No such constraints are under consideration. To the contrary, the more available, interoperable signals, the better. This is of particular interest in harsh GNSS environments such as urban, forested, moderate indoor, etc.
14	Is having more signals inherently better or do you think there should be a limit?	[QCOM] Of course, there are marginal returns as the number of available signals gets large, but in general, we believe "more is better", assuming that signals are interoperable and compatible. This is particularly important for urban and indoor scenarios.
14	Will the marketplace “force” you to make use of every available signal?	[QCOM] Competitive and market pressure do tend push GNSS devices to support available signals as they become operationally available, subject to aforementioned cost, size and power constraints.
14	For best interoperability, how important is a common center frequency? How important is a common signal spectrum (PSD)?	[QCOM] Qualcomm supports efforts to harmonize both center frequencies and signal bandwidth, promoting more interoperable GNSS signals.
15	Will you provide “tri-lane” capability in the future? Why?	[QCOM] Qualcomm cannot comment on forward looking product features, capabilities, or implementation details.

Qualcomm Interoperability Survey Response (4/5)

Slide No.	Question	Answer
15	If so, do you prefer a common middle frequency or the combined use of L2 (1227.6), B3 (1268.52), and E6 (1278.75) if B3 and E6 open access is available	[QCOM] Qualcomm has no opinion on this subject.
15	Would you prefer a common open signal in S Band? In C Band? Why?	[QCOM] Qualcomm has no opinion on this subject.
16	Does a wider satellite transmitter bandwidth help with multipath mitigation?	[QCOM] We expect this issue to be more of a concern in high precisions systems. As such, we have no comment.
16	What minimum transmitter bandwidth would you recommend for future GNSS signals in order to achieve optimum code precision measurements?	[QCOM] On the minimum side, Qualcomm would advocate the bandwidth used today for the L1 C/A code. Precision of code measurements on consumer grade devices is often dictated by antenna designs and placement, not signal bandwidth.
17	Would you recommend GNSS or SBAS services provide interoperability parameters (see list in slide)?	[QCOM] Qualcomm recommends that interoperability parameters be provided by GNSS or SBAS. Other options for obtaining this information may well be possible, but not always available.
17	Should they be provided by other means so as not to compromise TTFF or other navigation capabilities?	[QCOM] Qualcomm believes that interoperability parameters can be provided in a manner so as to minimize impact on TTFF. Alternative means for obtaining these parameters would also be useful. In summary, we prefer both options. To minimize impact on TTFF, Qualcomm would prefer minimizing the data transmitted by satellites to be just system clock offsets.
18	For your applications and for each signal, what amount of drift between code and carrier over what time frame would be excessive?	[QCOM] We expect these constraints to be much more demanding for high precisions systems. As such, we have no comment.

Qualcomm Interoperability Survey Response (5/5)

Slide No.	Question	Answer
18	For your applications and for two or more signals in different frequency bands, e.g., L1 and L5 (when scaled properly), what amount of relative drift in code and carrier between the signals would be excessive?	[QCOM] We expect these constraints to be much more demanding for high precisions systems. As such, we have no comment.
19	Should the international community strive to protect all GNSS signal bands from terrestrial signal interference?	[QCOM] Yes, it is important that GNSS signal bands not suffer interference. Qualcomm understands that interference is always subject to debate, so it is important that such debates be resolved with appropriate, reliable technical evidence.
20	Do the current differences (~10 cm) in Geodesy pose a problem for your users? Why or why not?	[QCOM] We expect these constraints to be much more demanding for high precisions systems. As such, we have no comment.
20	If geodesy differences are a problem, what is the preferred method of compensation (see list on slide)?	
21	Do you want each system to cross reference the other's time (e.g., with a GGTO type of message) or compare itself to a common international GNSS ensemble time? To what precision?	[QCOM] Qualcomm would find either approach acceptable. If a common international GNSS ensemble time is selected, we would strongly urge that it be defined to be discontinuity free (e.g., no leap seconds), to a few nanoseconds of precision or better.
21	Will your future receivers calculate a time offset between systems based on signal measurements or use only external time offset data?	[QCOM] Qualcomm cannot comment on forward looking product features, capabilities, or implementation details.
21	What is the preferred method of receiving time offsets: Satellite messages, Internet messages, or internally calculated?	[QCOM] Satellite messages. Other options may exist and can be pursued, but may not always be possible (e.g.,. Out of wireless coverage or barely determined scenarios where estimation is not possible).











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