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February 11, 2016

Ms. Marlene S. Dortch
Secretary
Federal Communication Commission
445 12th Street, SW
Washington, DC 20554

Re: Written *ex parte* presentation in RM-11681; IB Docket No. 12-340; IB Docket No. 11-109; IBFS File Nos. SES-MOD-20151231-00981, SAT-MOD-20151231-00090, and SAT-MOD-20151231-00091.

Dear Ms. Dortch:

Ligado Networks LLC ("Ligado") (née New LightSquared LLC) submits this *ex parte* presentation to demonstrate how the settlement agreement the company has reached with Garmin[1] will benefit not just that company, but will also flow to other GPS device manufacturers.

Garmin, an industry leader in the consumer GPS ecosystem, has stated that, in light of the substantially reduced operating parameters on Ligado's LTE operations, it does not object to Ligado deploying its LTE network in the bands 1627 MHz and above.[2] The question has arisen whether these operational limitations will benefit other GPS device manufacturers. As this submission establishes through the Declaration of Bill Alberth, former Chief Technology Officer at Motorola Mobility, and industry data presented in the attached GPS Device Market and

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[1] New LightSquared reached an agreement with Garmin International, Inc. on December 16, 2015. *See* Letter from Gerard J. Waldron to Marlene H. Dortch, IB Docket No. 12-340 (Dec. 17, 2015).

[2] Settlement Agreement and Releases between Garmin International, Inc. and New LightSquared LLC and LightSquared Subsidiary LLC, Dec. 17, 2015, at § 6; Exhibit D.

Ligado has also reached settlement agreements with Deere & Company and Trimble Navigation Limited. *See* Letter from Gerard J. Waldron to Marlene H. Dortch, IB Docket No. 12-340 (Dec. 8, 2015); Letter from Gerard J. Waldron to Marlene H. Dortch, IB Docket No. 12-340 (Feb. 3, 2016). Both of these companies have also stated that they do not object to Ligado's planned network deployment.

Supply Chain Overview ("GPS Industry Overview"), other GPS companies will reap the benefits of these changes by virtue of the integrated nature of the GPS industry supply chain.[3] GPS consumer devices are made up of a series of components, including antennas, filters, and chipsets, that are manufactured by a small number of suppliers.[4] These suppliers manufacture components for a variety of GPS consumer devices and sell those components to a number of device manufacturers.[5] For GPS consumer devices, the device manufacturer typically purchases these components off the shelf and does not modify them at all in constructing the device.[6] When component suppliers design these chipsets and filters, lead device manufacturers (such as Garmin for PNDs) will typically influence the designs to meet their product specifications.[7] Suppliers will then offer these chipsets and filters for sale to all consumer device manufacturers, as that increases volume and reduces cost.[8] Thus, Mr. Alberth concludes that any improvements, modifications, or other changes to components required by a market-leading firm like Garmin will result in an updated component not only being sold to that company, but also to all other GPS consumer device manufacturers.[9]

Garmin plays an important role in the GPS industry ecosystem. Garmin is the largest manufacturer of consumer-facing GPS devices, supplying eighty-four percent of the personal navigation device (PND) category.[10] Because of Garmin's substantial market share and due to the nature of the consumer GPS ecosystem, Mr. Alberth concludes that when Garmin begins implementing changes with its component suppliers in accordance with Ligado's newly-established technical operating parameters, the other GPS consumer device manufacturers, who purchase parts from a common set of component suppliers, will receive the benefit of any modified or improved performance delivered by the suppliers.[11] That ripple effect will ensure that, to the extent any modifications are necessary, other GPS consumer device manufacturers

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[3] The GPS Industry Overview was prepared with the assistance of the Brattle Group, which conducted the economic analysis, and with industry data provided by a nationally recognized management consultant firm. The industry data, including the expert interviews, were compiled over the summer of 2015, and the Brattle Group analysis was conducted in the fall of 2015.

[4] Alberth Decl. at ¶ 12; GPS Industry Overview at 5.

[5] Alberth Decl. at ¶ 9; GPS Industry Overview at 5.

[6] Alberth Decl. at ¶ 13; GPS Industry Overview at 5.

[7] Alberth Decl. at ¶ 12.

[8] *Id.*

[9] *Id.*

[10] Alberth Decl. at ¶ 8; GPS Industry Overview at 6.

[11] Alberth Decl. at ¶ 15.

will necessarily incorporate any such modifications and therefore those devices will be similarly unaffected by adjacent band signals from the planned Ligado operations.[12]

The limitations of Ligado's planned operations will be translated into practical consequences through 3GPP, the global standards setting body that supports implementation of new spectrum bands and features sets in LTE releases. Ligado will commence working with 3GPP as soon as the FCC takes action to modify the spectrum licenses. If the FCC were to modify the spectrum licenses by mid-2016, Ligado could commence working with 3GPP well before the next 3GPP release (currently scheduled for March 2017). That timetable would make it possible for Ligado to seek industry agreement and support for its spectrum to be incorporated in this 3GPP Release 14 for March 2017. Having the Ligado spectrum in LTE/3GPP Release 14 would then allow suppliers and ecosystem participants to support the delivery of chipsets, software, devices, and equipment that could utilize Ligado's band of spectrum. Mr. Alberth states that in his experience, it can take approximately eighteen to twenty-four months once the company's spectrum plan is in the standard (such as LTE/3GPP Release 14) before these bands can be utilized.[13] This timing will enable Ligado's planned operations to be part of the wireless industry's transition to 5G, with its tremendous capability to yet again revolutionize the mobility experience for consumers.

Please direct any questions to the undersigned.

Respectfully submitted,

/s/ Gerard J. Waldron

Gerard J. Waldron
Counsel to Ligado Networks LLC

Attachments

cc: Phil Verveer
Edward Smith
Louis Peraertz
Joanna Thomas
Erin McGrath
Brendan Carr
Julius Knapp

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[12] *Id.*

[13] Alberth Decl. at ¶ 16.

Ron Repasi
Bob Nelson
Roger Sherman
Charles Mathias
Paul Murray
Jon Chambers
Jennifer Tatel

Before the
Federal Communications Commission
Washington, D.C. 20554

	)	
	)	RM-11681; IB Docket No. 12-340;
In the Matter of	)	IB Docket No. 11-109; IBFS File
GPS Industry Supply Chain	)	Nos. SES-MOD-20151231-00981,
	)	SAT-MOD-20151231-00090, and
	)	SAT-MOD-20151231-00091

DECLARATION OF BILL ALBERTH

I. Introduction and Qualifications

1. My name is Bill Alberth. I am the former Vice President and Chief Technology Officer of Mobile Devices at Motorola Mobility. I am currently an advisor to Northwestern University's Department of Electrical Engineering and Computer Science. I serve as a member of the advisory board for NextNav, LLC, on the advisory board for SiNode, and I am a senior advisor for Argonne National Laboratories. I also am a senior consultant for the engineering consulting firm of Roberson and Associates.

2. I have deep experience in the wireless communications field. I have more than 155 patents issued or pending and consult with startups and established corporations on topics relating to technology, wireless technology, and intellectual property.

3. I have presented to the FCC on spectrum and other topics such as the use of FM radio receivers in cellular products.

4. I have over twenty-five years of experience in digital communications, systems engineering, digital signal processing, and new technology introductions and I have product development experience in a variety of technologies.

5. I earned an MSEE from the Illinois Institute of Technology and a BSEE from the University of Illinois Urbana-Champaign.

6. Based on my twenty-five years of experience in this field, and my review of GPS industry data supplied to me ("GPS Industry Consultant's Report"), it is my opinion that the settlement agreement reached between LightSquared and Garmin will cause a ripple effect throughout the GPS industry, resulting in all GPS consumer device manufacturers receiving the benefit of the Garmin-LightSquared agreement. GPS device component manufacturers will develop components consistent with the terms of the Garmin-LightSquared agreement to be both adequate to ensure compatibility with LightSquared operation and feasible to deliver. The GPS consumer device industry, to a large extent, shares a common supply chain and uses similar or identical GPS consumer device component parts, especially chipsets and filters. Given industry practices, other GPS device manufacturers will develop GPS consumer devices employing components (including antennas, filters, and receiver systems) that are identical or similar to the components used by Garmin. Consequently, the same operational limits on LightSquared established by the Garmin-LightSquared agreement will benefit other GPS consumer device manufacturers, resulting in a degree of operational compatibility equal to that secured by Garmin.

II. General Location and Navigation Devices

7. GPS is used in a wide variety of applications. The GPS Industry Consultant's Report identifies six different categories of the GPS receiver market: general location and navigation (GLN); cellular; automobiles; high precision; certified aviation; and timing. Based on my experience and a review of the FCC's record, I am not aware of any concerns raised about LightSquared's planned operations by cellular handset manufacturers, which represent the largest of the six GPS device categories. Cellular devices typically include GPS receivers and are required to meet 3GPP performance criteria. Cellular devices include multiple transmitters (cellular in multiple bands, Bluetooth, Wi-Fi, etc.) collocated with the GPS

receiver which necessitates a design tolerant of other signals. My analysis focuses on the GLN device category, which is the second largest of the six GPS devices categories and is made up of sub-categories such as personal navigation devices (PNDs) and wearable/outdoor devices. Garmin is the largest single GPS device manufacturer in the GLN consumer category.

8. PND devices make up the largest of the five sub-categories within the GLN consumer category. According to the GPS Industry Consultant's Report, as of 2015, Garmin supplies eighty-four percent of the PND market. Garmin also serves other GLN consumer device sub-categories like wearables/outdoor, marine, asset tracking, and non-certified aviation.

9. Although there are several device manufacturers across these five GLN sub-categories, all of these consumer device manufacturers, including Garmin, typically purchase their GPS components (such as antennas, RF front end parts, and GPS chipsets) on an off-the-shelf basis from a common set of suppliers and then integrate those components into their devices. For example, Mediatek, one of Garmin's suppliers, is a module and chip manufacturer in both the PND and wearable/outdoor sub-categories. It is my experience that suppliers like Mediatek generally sell the same component to multiple consumer GPS device manufacturers. This means that these component parts for consumer GLN devices will be designed into devices made by different consumer device manufacturers. As a consequence, it is my experience that improvements, modifications, or other changes to components required by a market-leading firm like Garmin will result in an updated component sold not only to Garmin, but also to other, smaller GPS device manufacturers.

10. The specific types of GPS components, which GPS consumer device manufacturers purchase from suppliers, include the antennas, filters, and chipsets, which may be sourced as separate components or sourced as a module.

11. The antenna subsystem design is a critical component for defining GPS receiver performance. Antennas may be designed and/or sourced from third party suppliers and are usually designed around the packaging constraints of the product.

12. Chipsets and filters are procured from a small base of suppliers. Chipset and filter development typically requires a large investment of resources to design and generate mask works and to validate the design. When these filters and chipsets are designed, typically lead devices OEMs (such as Garmin for PND devices) will influence the designs to meet their product needs. The chipsets and filters developed by suppliers are typically offered for sale to all device OEMs, which increases volume and reduces cost. It is my understanding that chipsets and filters supplied to and used by Garmin in devices compatible with LightSquared's planned deployment will be available to all non-Garmin consumer device OEMs.

13. The GPS Industry Consultant's Report states that, for its personal navigation devices, Garmin purchases its antennas, filters, and chipsets off-the-shelf from third-party suppliers. The GPS Industry Consultant's Report further states that suppliers also control the design of the antennas, filters, and chipsets for other consumer-facing GPS devices, including wearables, marine, asset tracking, and non-certified aviation devices. Garmin and other individual manufacturers of these devices provide suppliers with their product specifications and then integrate off-the-shelf components that are designed by their suppliers. It is my understanding that they do not alter the design of the GPS components they purchase.

14. To the extent that Garmin has already started implementing changes with its component suppliers to its GPS receiver architecture and related key components in accordance with these newly-established technical operating parameters, it is my opinion that non-Garmin consumer device manufacturers, who purchase from a common set of component suppliers, will receive the benefit of any modified or improved performance delivered by component suppliers. This will ensure that, to the extent any modifications are necessary, these non-Garmin consumer devices will receive them and will be similarly unaffected by adjacent band signals from the planned LightSquared operations.

15. In the event that Garmin has not already started that implementation process, if any protections for consumer device performance are necessary, they can rapidly be delivered into the GPS consumer device market. According to the GPS Industry Consultant's Report, the turnover for consumer-facing GPS devices is fairly rapid (e.g. an average of two years for PND devices). I will use the example of PNDs — the largest category of consumer-facing GPS devices — to illustrate the effect of this rapid turnover. PNDs are an indicative category, as they use an off-the-shelf supply chain and have frequent new sales and device replacements, like other consumer-facing GPS device categories. As the GPS Industry Consultant's Report indicates, there are a total of 2.08 million non-Garmin PND devices in 2015. For purposes of demonstrating how new device sales and device retirements have the combined effect of changing the projected 2020 installed base of non-Garmin PND devices, by 2020 only 200,000 in service non-Garmin PNDs will have been manufactured before January 1, 2018. This changing consumer composition is driven by the two dynamics of customers retiring old models and customers buying newer models. If the FCC were to modify LightSquared's licenses in accordance with technical operating parameters proposed in the December 31, 2015 filings, it is

my opinion that non-Garmin consumer device manufacturers, to the extent any device performance issue were to exist, could implement any necessary changes into their GPS receiver architecture and include prospective component specification changes such that all non-Garmin device sales starting January 1, 2018 would not experience any performance issue related to adjacent band operations. Based on my experience, I expect that virtually all consumer GPS devices on the market, regardless of manufacturer, will be composed of the same off-the-shelf parts (especially chipsets and filters) made by a small number of suppliers who supply a variety of device manufacturers. Therefore, to the extent that Garmin has negotiated for operational limits on LightSquared that result in LightSquared's handsets not causing harm to Garmin consumer devices, those same limits will benefit other GPS companies because device manufacturers in the GPS industry to a large extent share a common supply chain and thus use similar or identical GPS device component parts.

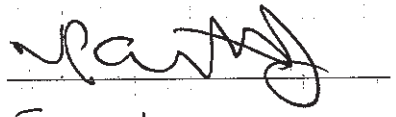
III. Additional Insights

16. LightSquared has proposed various operational limitations on its license and network deployment. In my industry experience, these limitations will be translated into practical consequences through 3GPP, the global standards setting body that supports implementation of new spectrum bands and features sets in LTE releases. In my experience, a company in LightSquared's position likely will commence working with 3GPP as soon as the FCC takes action to modify the spectrum licenses. For example, if the FCC were to modify the spectrum licenses by mid-2016, it is reasonable to expect LightSquared to commence working with 3GPP well before the next 3GPP release (currently scheduled for March 2017 [Stage 3 freeze target date]). That timetable would make it possible for LightSquared to seek industry agreement and support for its spectrum to be incorporated in this 3GPP Release 14 for March 2017. Having the LightSquared spectrum in LTE/3GPP Release 14 would then allow suppliers

and ecosystem participants to support the delivery of chipsets, software, devices, and equipment that could utilize LightSquared's band of spectrum. In my experience, it can take approximately eighteen to twenty-four months once the company's spectrum plan is in the standard (such as LTE/3GPP Release 14) before these bands can be utilized.

IV. Conclusion

17. Based on my twenty-five years of experience designing and shipping consumer wireless products and my review of the GPS Industry Consultant's Report, it is my opinion that the settlement agreement reached between LightSquared and Garmin will have a ripple effect throughout the manufacturing supply chain for consumer GPS devices, enabling other consumer GPS device manufacturers to make their devices with components that are identical or similar to the ones being used by Garmin. Therefore, due to the common supply chain device manufacturers in the GPS consumer device industry share and that Garmin has negotiated for operational limits that result in LightSquared's handsets and base stations not impacting Garmin consumer GPS devices, those same limits will effectively ensure the compatibility of consumer GPS devices manufactured by other manufacturers.

Signed: 

Date: Feb 10, 2016

Firm: Roberson and Associates LLC

GPS Device Market and Supply Chain Overview

FEBRUARY 2016

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Summary Of GPS Device Categories And Applications

Categories	Applications	Description	Example Device	Companies
General Location / Navigation (GLN)	Portable Navigation (PND)	Aftermarket electronic systems designed to provide location information and directions to a destination	Windshield mounted GPS unit	GARMIN, TOMTOM, MAGELLAN
	Wearables / Outdoor	Personal navigation and lifestyle devices, including those used for cycling, hiking, golf, and smartwatches	Smartwatch	GARMIN, TOMTOM, fitbit, JAWBONE
	Marine / Asset Tracking / Non Certified Aviation	Devices used for other GLN applications, such as asset tracking marine navigation and certified aviation	Marine navigation devices	Trimble, GARMIN
Cellular	Smartphones / Tablets	Cellular phones with Internet access and an operating system capable of providing navigation via GPS, cellular data, and additional built-in components or software	iPhone	SAMSUNG
Auto	In-Dash	Factory installed units designed to provide in-car navigation; sometimes part of a multi-function infotainment system	In-dash navigation portal	HARMAN, ALPINE, DENSO, BOSCH, MITSUBISHI
High precision	Agriculture	GPS receivers used in precision farming for applications such as farm planning, field and yield mapping, soil sampling, tractor guidance	GPS receiver installed on a tractor	Trimble, TOPCON, JOHN DEERE
	Construction	GPS receivers used on construction equipment for navigation, asset tracking, and fleet management	GPS used on earth moving equipment	Trimble, Leica, TOPCON
	Surveying	GPS receivers used to gather data for the modeling and documenting of the physical world that can be displayed on maps and used in geographic information systems (GIS)	Vehicle mounted GPS receiver used by land surveyor	Trimble, Leica, TOPCON
Aviation	FAA Certified	Navigation devices that enable three-dimensional position determination for aircraft in flight or during takeoff / landing	In-flight navigation system	Rockwell Collins, Honeywell, GARMIN
Timing	Timing for Networks	GPS receivers that decode the time dimension of GPS signals, synchronizing the receiver's time to the satellites' atomic clocks; precise time is supplied to communication systems, electrical power grids, and financial networks	GPS receivers installed in power plants	ublox, Trimble, Microsemi

Estimated And Projected Market For GPS Devices In The U.S.

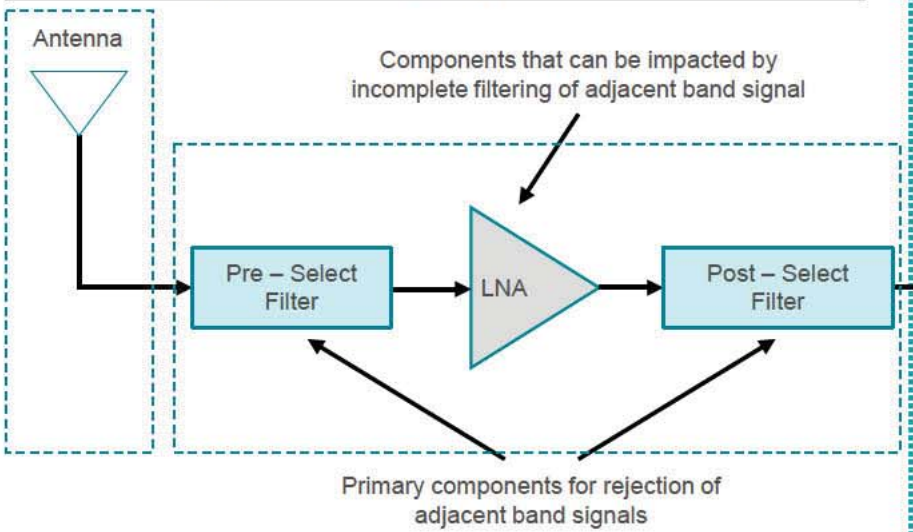
Categories	Applications	Installed Base (mn units)		Units Sold (mn units)
		2015	2020	2015
GLN	PND	13.00	6.44	5.25
	Wearables / Outdoor	10.27	34.32	6.67
	Marine	3.84	3.99	0.48
	Asset tracking	9.80	19.78	1.45
	Non-Certified Aviation	0.06	0.07	0.01
	Total	**36.97**	**64.60**	**13.85**
Cellular	Smartphones	223.61	263.46	169.30
	Tablets	93.93	160.53	34.46
	Total	**317.55**	**423.99**	**203.76**
Autos	In-Dash	22.18	44.64	4.84
High Precision	Agriculture	0.17	0.19	0.03
	Construction	0.19	0.23	0.03
	Surveying	0.16	0.19	0.03
	Total	**0.51**	**0.60**	**0.09**
Aviation	Certified Aviation	0.13	0.13	0.01
Timing	Timing for Networks	1.94	2.09	0.19
Grand Total		**379.28**	**536.05**	**222.74**

Certified Aviation includes general and commercial aviation devices.
Non-Certified Aviation includes handheld devices.

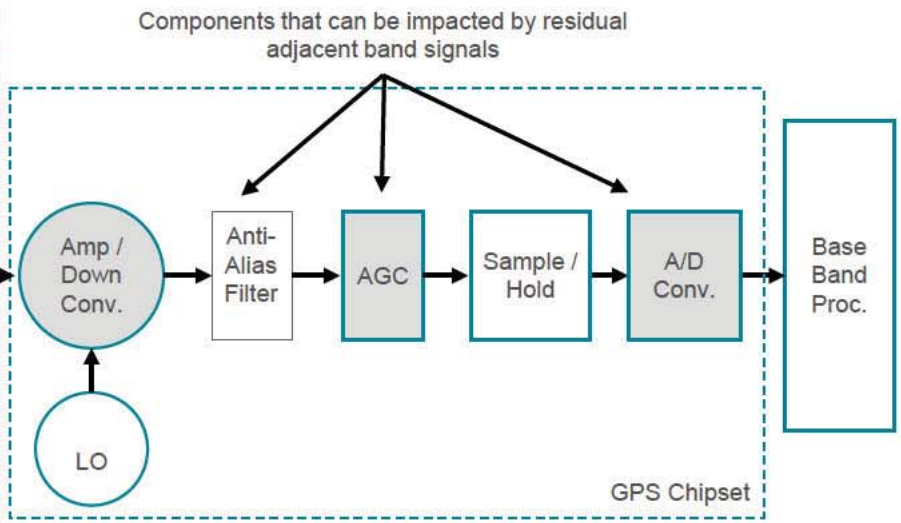
GPS Receiver Architecture And Key Components Overview

GPS receiver system – reference architecture

Antenna subsystem (analogue portion)



Receiver subsystem



Key points

- Antenna sub-system design is most critical in defining GPS receiver performance
- Type and performance of filters determines compatibility with adjacent band operations
- Filter, LNA and TCXO market is mature – well defined players with little technology differentiation
- Receiver subsystem typically purchased from chipset vendors (except high precision and aviation)
- Fewer designs / archetypes being offered: example- Qualcomm offers 1-2 chipsets v/s 10-12 earlier
- In case of space constrained applications, GPS chipset and base band are integrated on a single IC

- Receiver system design and value chain depends on the application and its requirements around:
  - **Space (volume / area)**
  - **Power consumption**
  - **Accuracy**

Supply Chain Overview Of The GPS Receiver Market

Supplier controls design | OEM defines specifications, supplier designs | Device OEM controls design

Category / Application		Device OEM	Suppliers (examples)	Antenna Subsystem: Antenna	Antenna Subsystem: RF front-end (LNA, filter)	Receiver Subsystem: GPS Chipset / RF IC	Antenna/RF Front-end/Chipset Vendors
General Location/ Navigation	1 PND	▪ Garmin ▪ TomTom	▪ ST Micro, SiRF, Mediatek				Sourced with off-the-shelf components from suppliers that meet OEM specs
	2 Wearables / Outdoor	▪ Garmin ▪ Fitbit	▪ ST Micro, Mediatek				Antenna design outsourced, RF FE / IC typically purchased as solution
	3 Marine / Asset Tracking	▪ Garmin ▪ Trimble	▪ ST Micro, Furuno, Mediatek				Off-the-shelf RF FE, receiver modules. Device OEM responsible for system level architecture and integrates.
	4 Non-Certified Aviation	▪ Garmin	▪ Texas Instruments				System design done by Device OEM using off-the-self receivers
Cellular	5 Tablets / Smartphones	▪ Apple ▪ Samsung	▪ Qualcomm (QC), Broadcom				Antenna and RF Front End design in-house. Chipset is typically outsourced.
Auto	6 In-Dash	▪ Denso ▪ Harman ▪ Panasonic	▪ U-blox, Mediatek, Furuno/eRide, Broadcom, QC				Device OEM defines antenna specs but typically purchases complete RF module (RF FE + RF IC) from suppliers
High Precision	7 Agriculture	▪ Trimble ▪ Topcon ▪ Leica ▪ Deere	▪ Jabil, Flextronics, NavCom, Phoenix International				Antenna design is mostly done in-house. RF Front ends are almost always designed in-house. GPS Chipset is custom designed in-house.
	8 Construction						
	9 Surveying						
Aviation	10 FAA Certified Aviation	▪ Rockwell ▪ Honeywell	▪ semiconductor foundries – e.g. UMC and TSMC				Entire system and component (antenna, RF FE & IC) design done by device OEMs
Timing	11 Time for Networks	▪ Trimble, ▪ Microsemi	▪ Benchmark				Device OEMs are responsible for end-to-end design and integration of antenna, RF FE, and chipsets.

SOURCE: Expert interviews

Garmin Represents A Significant Portion of PND Devices

Estimated PND Devices in the United States (2015)

Manufacturer	Estimated installed base (2015), millions of units	Market Share (2015), %
GARMIN	10.92	84 %
TOMTOM	1.95	15 %
MAGELLAN	0.13	1 %
Total	13	

PND

Key points

- **Garmin represents 84% of the estimated 2015 installed base of PND devices**

Architecture

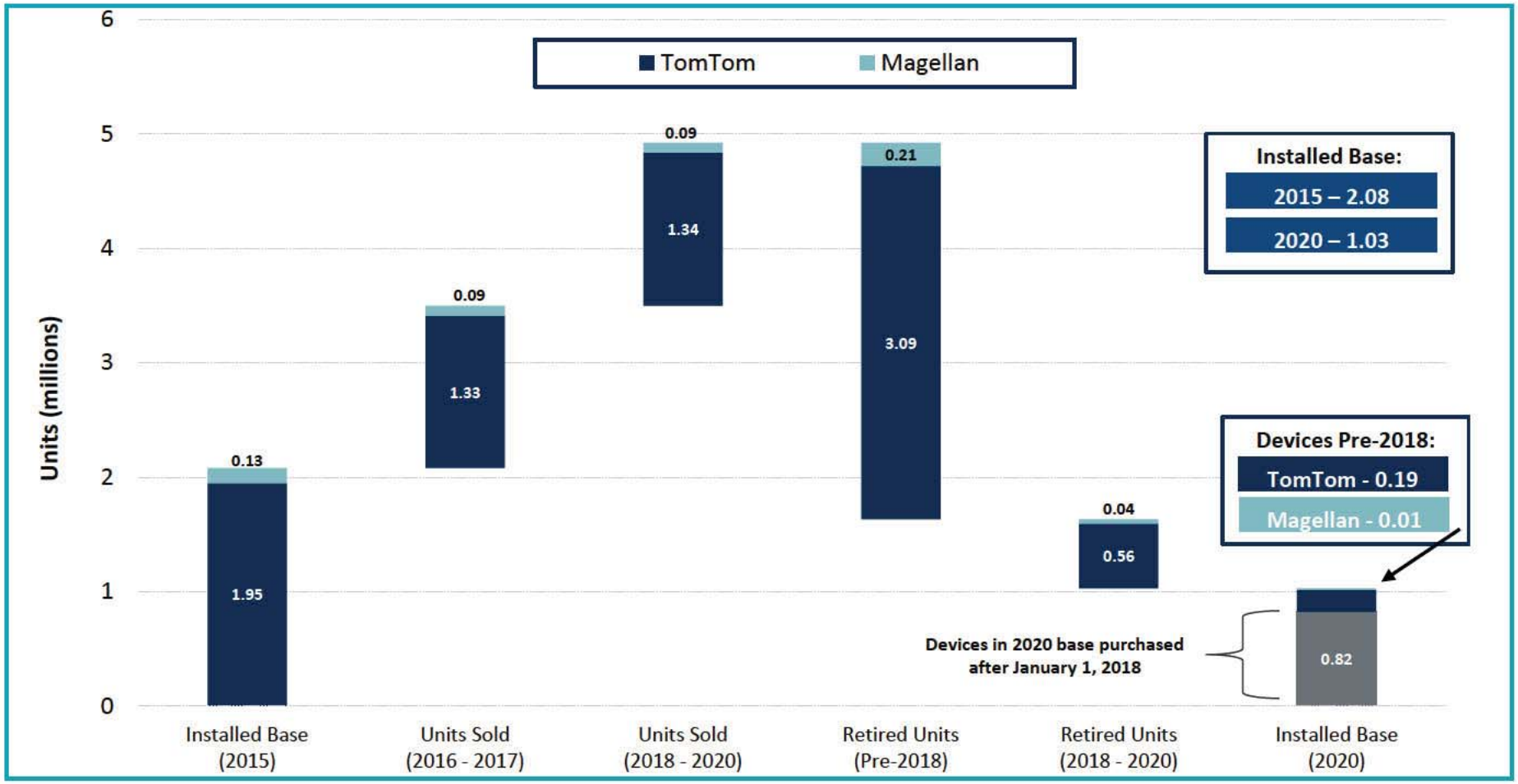
- **Device manufacturers typically purchase off-the-shelf GPS components from suppliers (antenna & receiver subsystems)** and integrate in their devices
  - For its PNDs, Garmin purchases all components off-the-shelf from suppliers

Suppliers

- **Key suppliers:**
  - **PND:** ST Micro, Mediatek, Broadcom, Qualcomm (ex-Atheros)
- **Garmin uses Mediatek and ST Micro GPS receiver solutions**

SOURCES: Berg Insight; Consumer Technology Association; expert interviews; Brattle Group internal estimates

Evolution Of The Projected 2020 Installed Base For Non-Garmin PND Devices[1]



- Out of the **2.08 mn** devices that are part of the estimated 2015 non-Garmin PND installed base, only **0.20 mn** devices remain in the projected 2020 non-Garmin PND installed base that were purchased prior to January 1, 2018.[2]

1 Assumes all non-Garmin devices, if not already compatible with planned LightSquared operations in adjacent bands, would be so on device sales sold after Jan. 1, 2018.
2 PND devices have an estimated average implied retirement rate of 2.0 years

SOURCES: Berg Insight; Consumer Technology Association; expert interviews; Brattle Group internal estimates