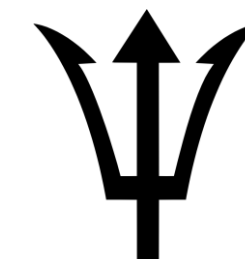




Neptune Project

NAVISP Element 2 – 129

Final Presentation



Taoglas



Antennas & RF Components

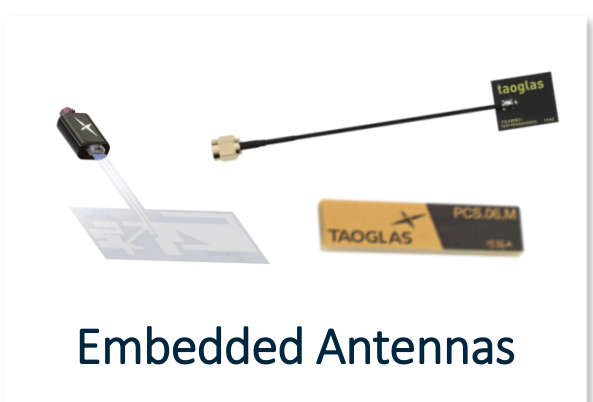
"You don't get connectivity and smart without an antenna."



“Hardware”



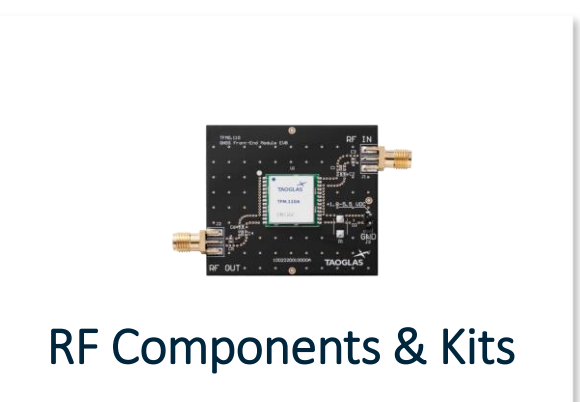
External Antennas



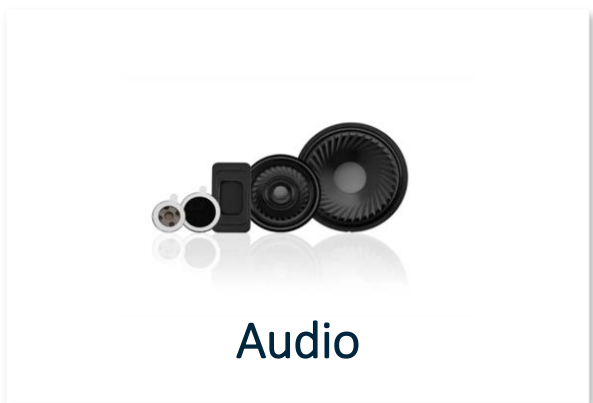
Embedded Antennas



Cables & Connectors



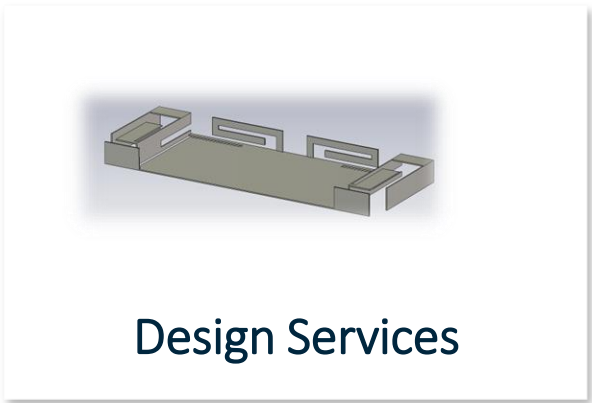
RF Components & Kits



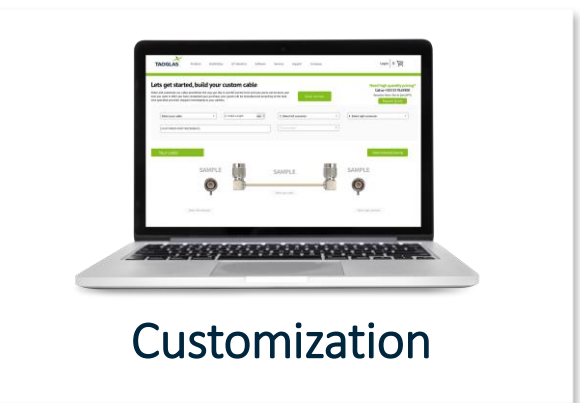
Audio



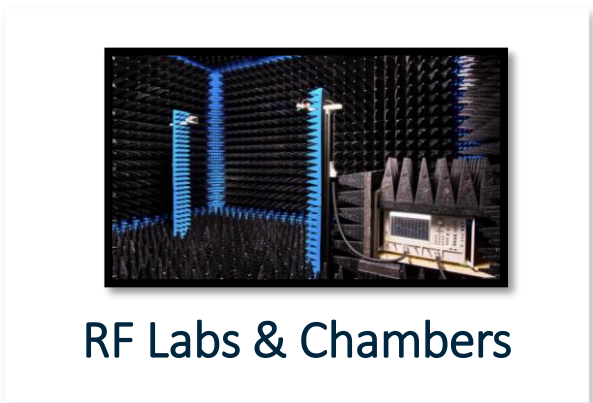
Magnetics



Design Services



Customization



RF Labs & Chambers



Pre-certification



Equipment & Testing



Design-for-Manufacture



Reliability & QC



Engineering Expertise



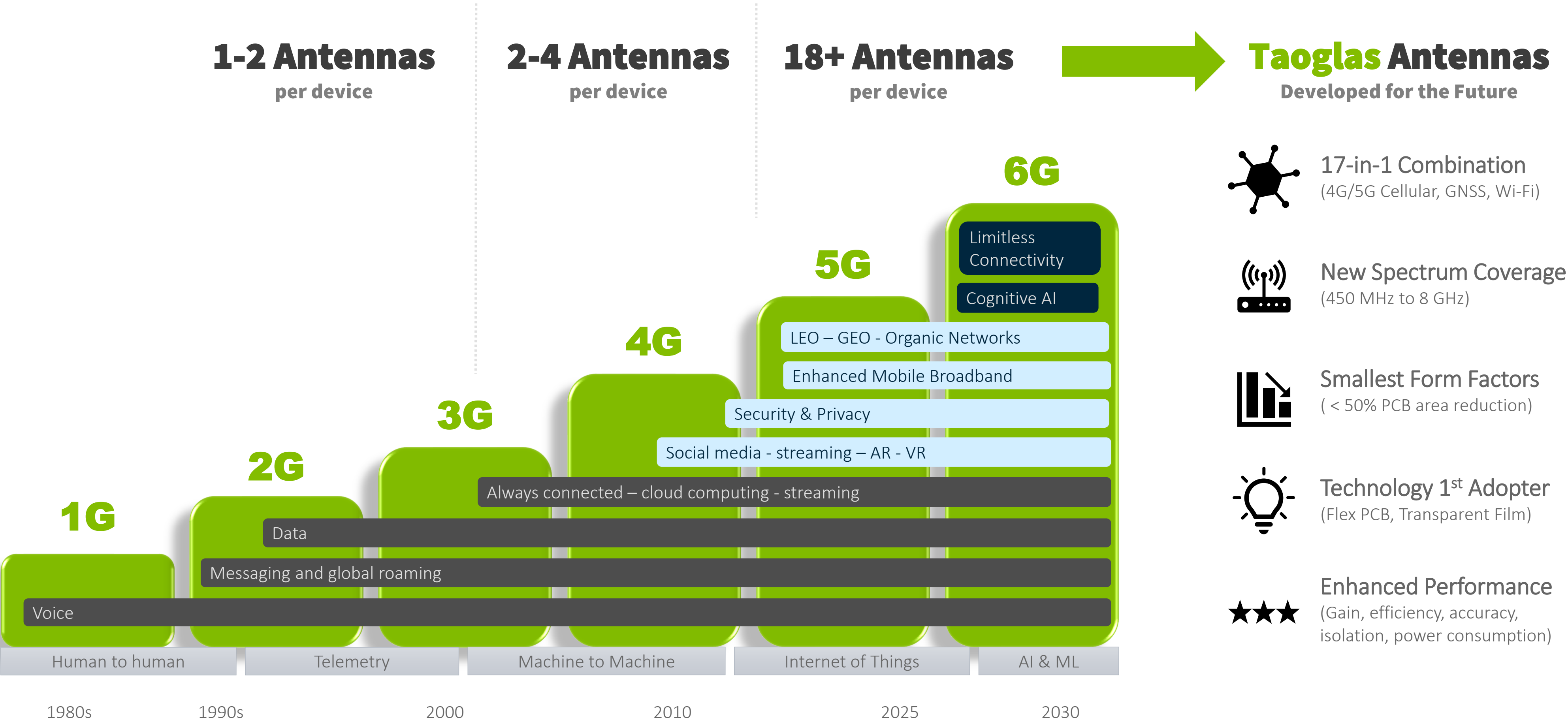
20+ Years Trusted Quality and Innovation





Taoglas Simplifies Complex Wireless Integration Requirements

"5G is only 5% of the marketplace today."



Taoglas at a Glance...

TAOGLAS
Founded in
2004

3,000+
 **Antenna
Designs**
Custom and off-the-shelf



Broadest
Antenna Portfolio
in the Industry



Unique
Industry-first Online
Cable & Antenna Builders


**Strong
Engineering
Capabilities**
Innovating
through R & D

 **20
Chambers
Worldwide**

**100
Engineers**
120+
Patents,
45 Pending


440+
Employees



10
Facilities
Worldwide

200 +
NPI Per Year

Servicing
20K+
Customers globally

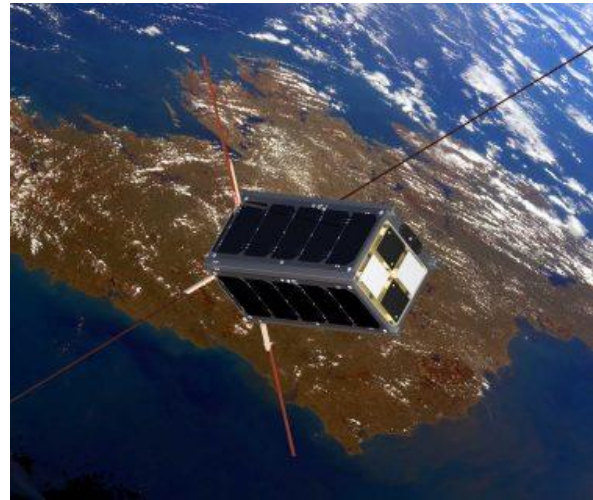
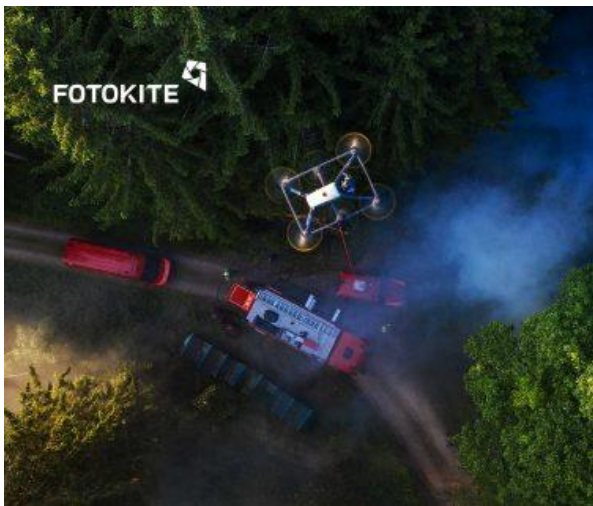
40,000+
Part Numbers



Worldwide 24/7
**Customer
Support**

Top 6 Market Verticals Through **Customer Success** Stories

"As IoT grows beyond early adopters, companies will need suppliers like Taoglas to support them on a global scale, and Taoglas can do that today."

Smart Transportation	Mobility & Infrastructure	Smart Industrial	Connected Health	SatComm & Aerospace	Smart Cities & Homes
 Taoglas antennas, cables, and audio wirelessly connect high quality, big and medium-size trucks while on the road.	 Basetime ultra-accurate geometric height measurement for construction applications	 Meet Serve, the four-wheeled courier bot shaping the future of sustainable, self-driving delivery	 ResMed CPAP machines for people who need help breathing at night	 Taoglas is shooting for the stars in Ireland's first-ever EIRSAT-1 satellite	 Bevi's connected innovative beverage dispensers in thirsty environments
 Taoglas drives enduring reliability for Control telemetry systems with flexible wideband antenna	 Pantheon antennas keep Police Department reliably connected	 qiio received Network Optimized Certification from AT&T® for their plug-and-play, edge-to-cloud cellular IoT solutions that securely connect, monitor, and control industrial assets	 HealthBeacon's custom solution that automatically monitors and helps manage patient medication management and compliance levels	 Fotokite's tethered drone	 Qolsys IQ Panel 4, designed using Taoglas antennas, achieved carrier certification with maximum range performance.



NAVISP Element 2 Neptune Project 129

Neptune Project

- Context and Rationale for Development
- Product Overview
 - Product 1
 - Product 2
 - Product 3
 - Product 4
- Rooftop Setup
- Field Test Results
- Conclusion of results
- Future Growth
- Benefits of working with ESA



Neptune Project – Context and Rationale for development.



In a previous project, Taoglas had developed a multiband GNSS antenna, and the outcome of that project created commercial benefits for Taoglas.

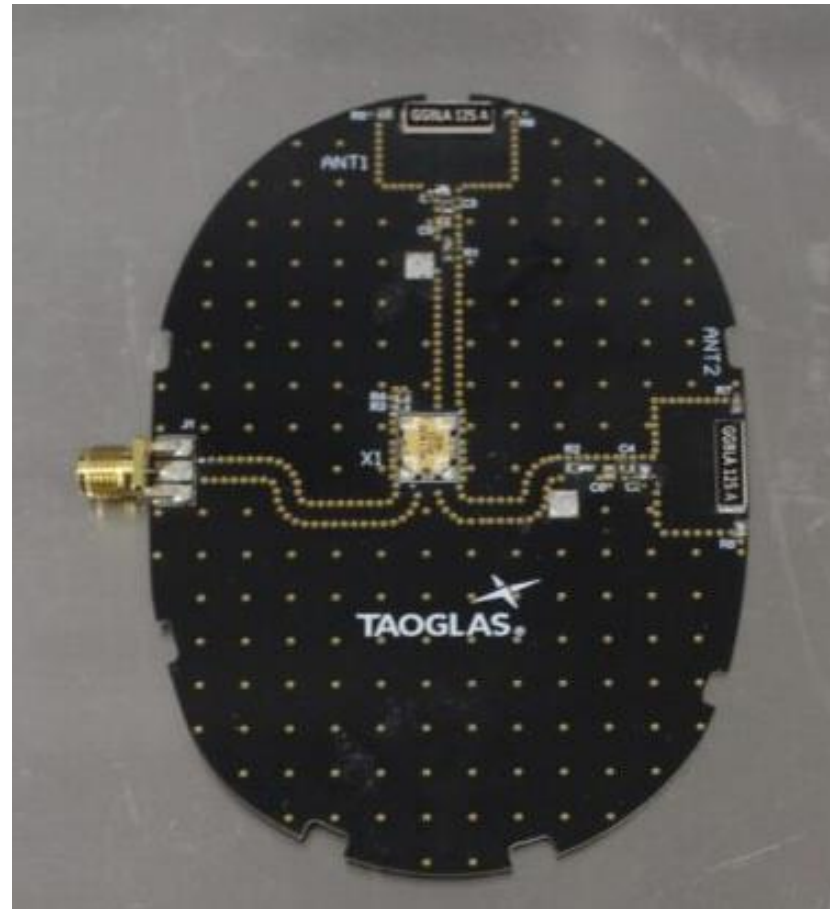
This included a market share increase where we witnessed more than 10% growth.

This growth came from sectors such as agriculture and autonomous mowers.

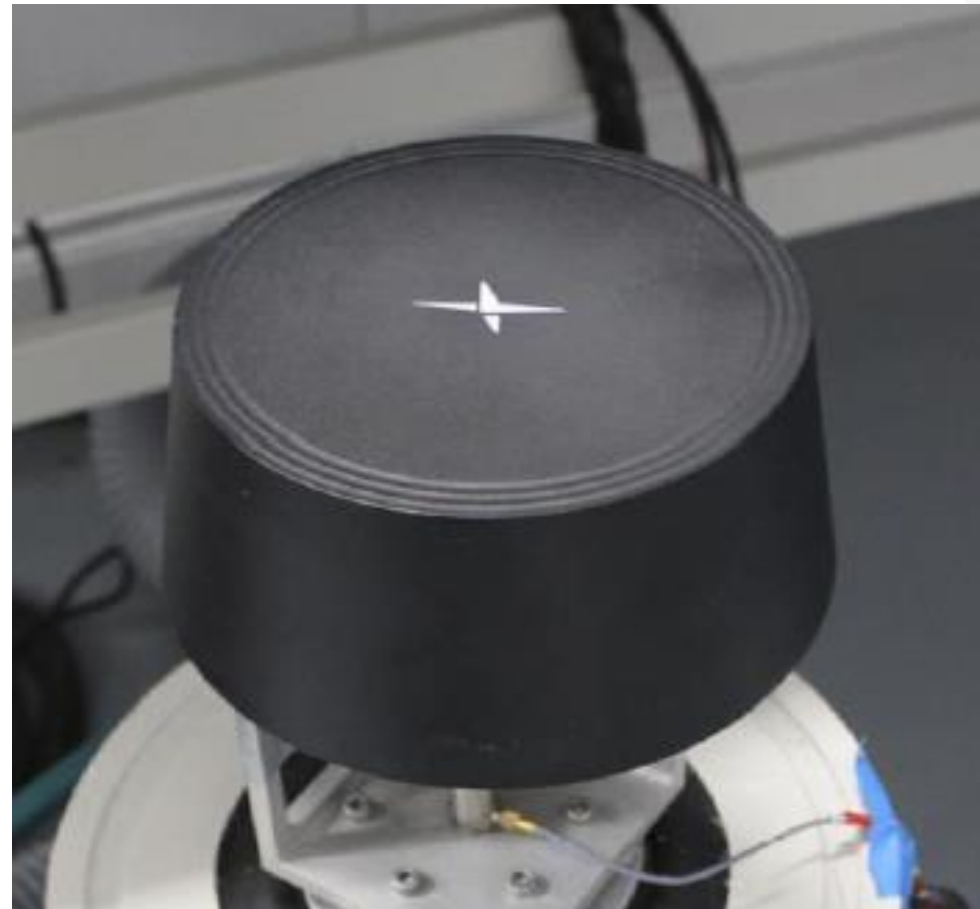
The Neptune project was created as an innovative evolution to multiband GNSS products by leveraging our knowledge in manufacturing & performance and combining multiband GNSS with other technologies to give additional options to our customers. Combination antennas would have been single band but now Taoglas are offering multiband GNSS alongside other technologies such as Cellular, Wi-Fi or ISM.



Neptune Project – Product Overview



Product 1: Compact omnidirectional GNSS multiband SMD Ceramic antenna



Product 2: External Combination Antenna with Multiband GNSS Antenna Solution with Cellular and Wi-Fi antennas



Product 3: Embedded Multiband GNSS with WiFi/ISM Technology



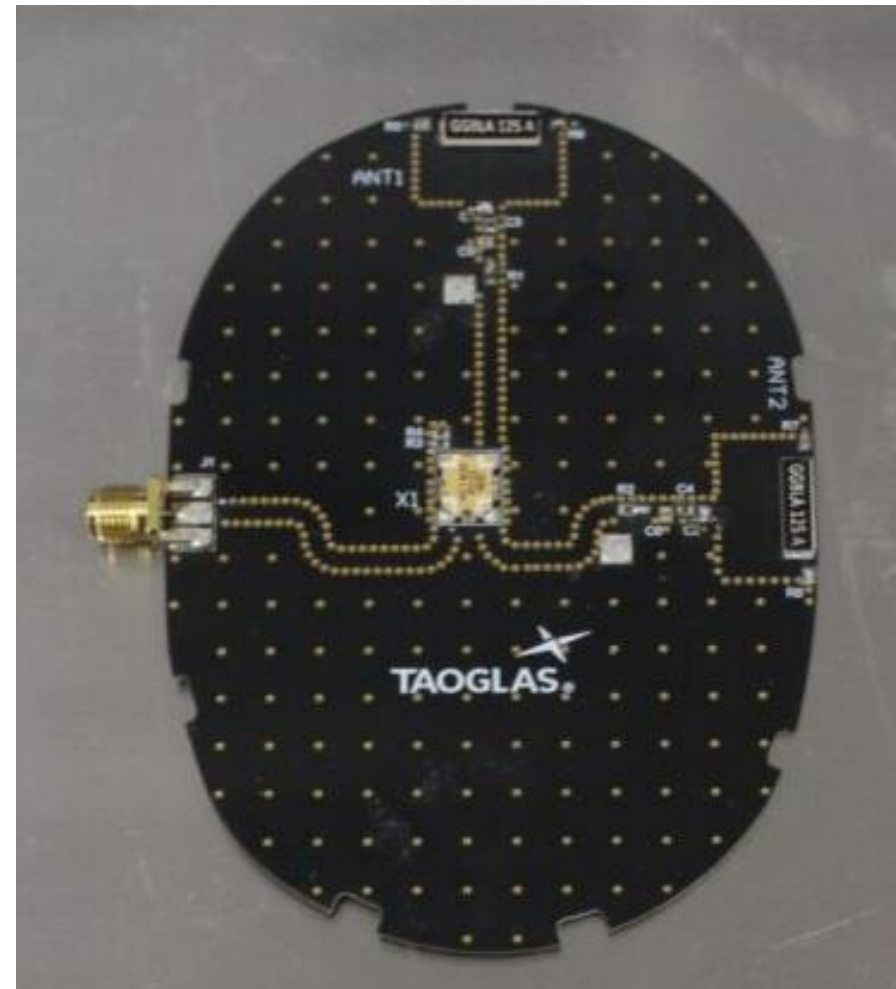
Product 4: Multiband GNSS antenna for Marine Application

These 4 products were built to help our customers solve various problems.



Neptune Project – Product 1

Compact omni-directional
GNSS multiband SMD
Ceramic antenna



Constellations and Bands covered :

- GPS (L1/L2/L5)
- Galileo (E1/E5a/E5b/E6)
- GLONASS (G1/G2/G3)
- BeiDou (B1/B2a/B2b/B3)

Key design principles

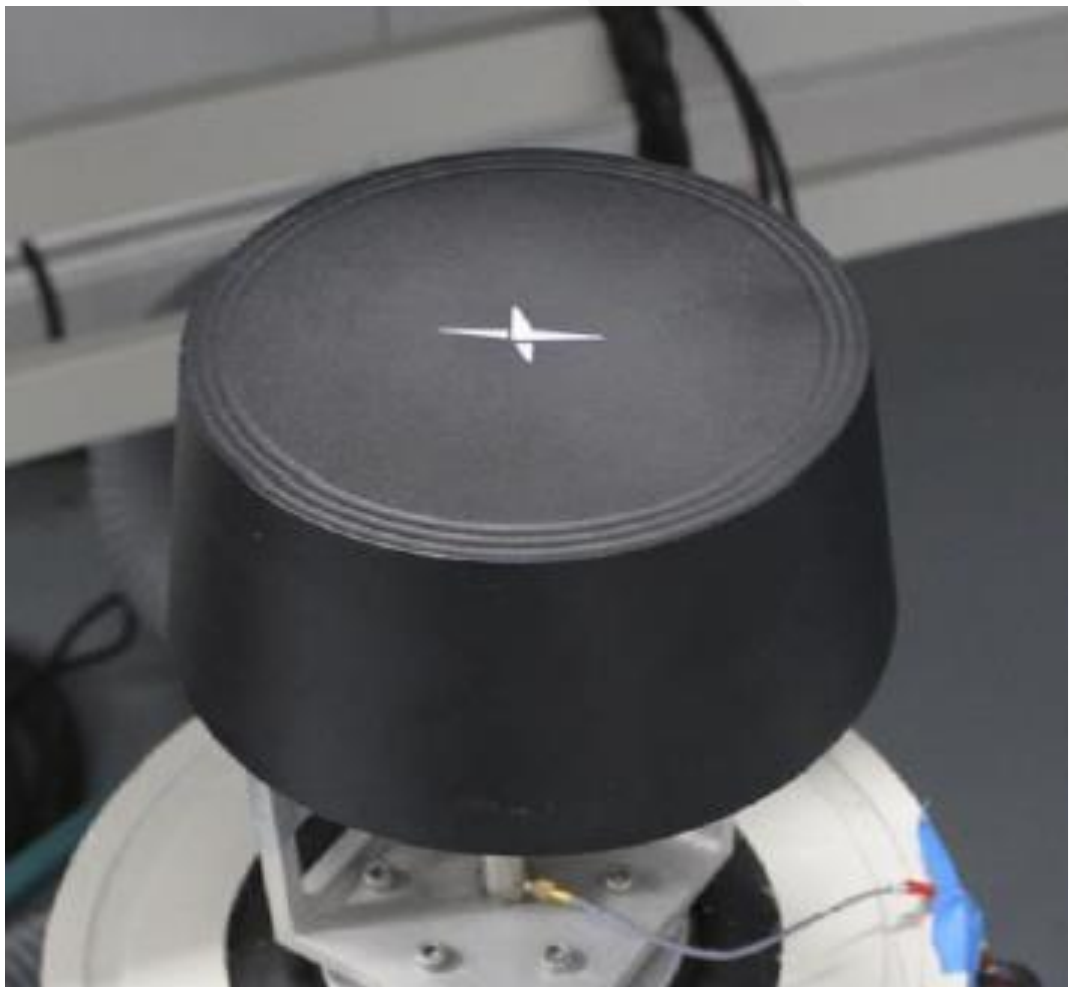
A compact RHCP multiband GNSS antenna solution suitable for mobile use cases where the dynamic orientation of the product is a requirement.

- Omni-directional solution
- Right Hand Circular Polarised
- Compact for hand-held and wearable devices



Neptune Project – Product 2

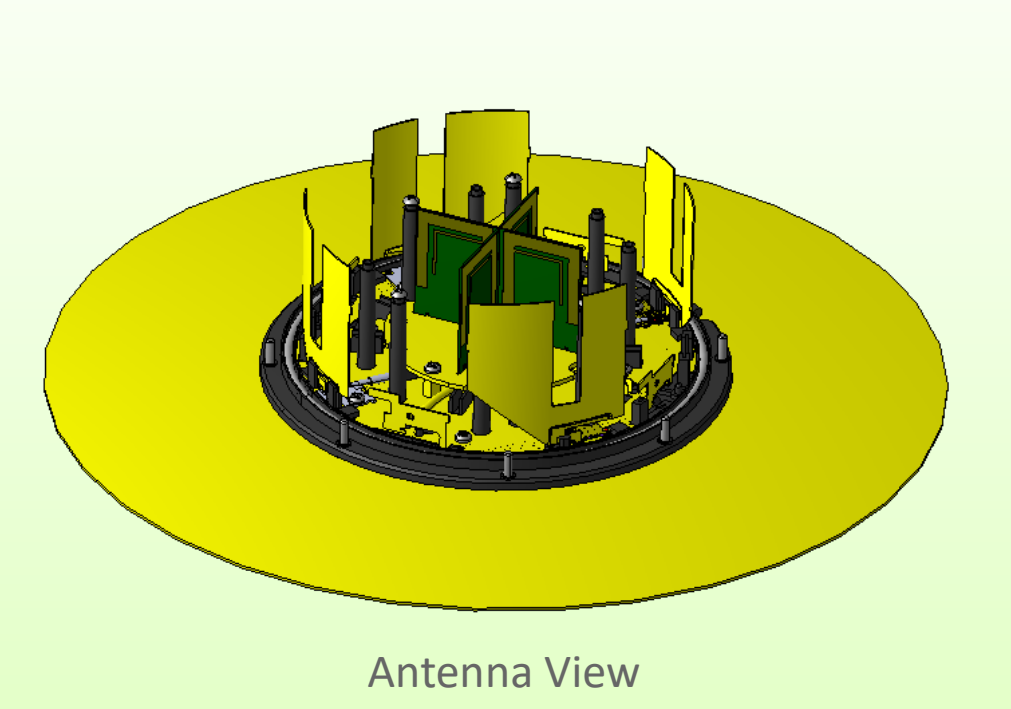
External Combination Antenna
with Multiband GNSS Antenna
Solution



Constellations & Frequency		
GNSS	Cellular	Wi-Fi
GPS (L1/L2/L5) Galileo (E1/E5a/E5b) GLONASS (G1/G2/G3) BeiDou (B1/B2a/B2b)	698MHz – 960MHz 1710MHz – 2690MHz	2.4GHz – 2.5GHz

Key design principles

External Combination antenna (Cellular/WiFi) with Multiband GNSS Antenna Solution for cm level positioning



- Modular solution
- Simplify integration
- Optimum GNSS performance alongside other radio technology performance.



Neptune Project – Product 3

Embedded Multiband
GNSS with WiFi/ISM
Technology



Constellations & Frequency		
GNSS	Wi-Fi	ISM
GPS (L1/L2/L5) Galileo (E1/E5a/E5b) GLONASS (G1/G2/G3) BeiDou (B1/B2a/B2b)	2.4GHz – 2.5GHz	868MHz/915M Hz

Key design principles

Embedded Multiband GNSS with
WiFi/ISM Technology for cm level
positioning

- Modular solution
- Simplify integration
- Optimum GNSS performance alongside other radio technology performance.

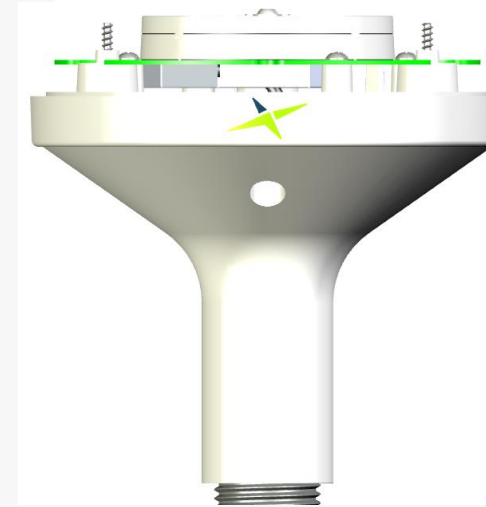


Neptune Project - Product 4

Multiband GNSS antenna for Marine Application



Multiband GNSS antenna for Marine application – used for marine shipping, coastal navigation, port approaches, leisure craft.



GNSS constellations covered:
GPS (L1/L2/L5)
Galileo (E1/E5a/E5b/E6)
GLONASS (G1/G2/G3)
BeiDou (B1/B2a/B2b/B3)

Key design principles

- Multiband High Precision GNSS solution
- Mechanical robustness for marine market requirements
- Low cost solution



Neptune Project – Rooftop setup

The rooftop setup consist of:

- 2 x Asterx-U Septentrio multiband GNSS receivers
- 2 x u-blox F9P receivers
- Network Switch
- Small Form Factor Computer

Number of measurement taken: 15

Mean Test Duration : 4 hours without correction
4 hours with correction



Neptune Project – Rooftop setup



Swift Navigation provided the PPP-RTK correction service through NTRIP using the Septentrio receivers.



PointPerfect from u-blox provides the PPP-RTK correction service through the MQTT protocol.

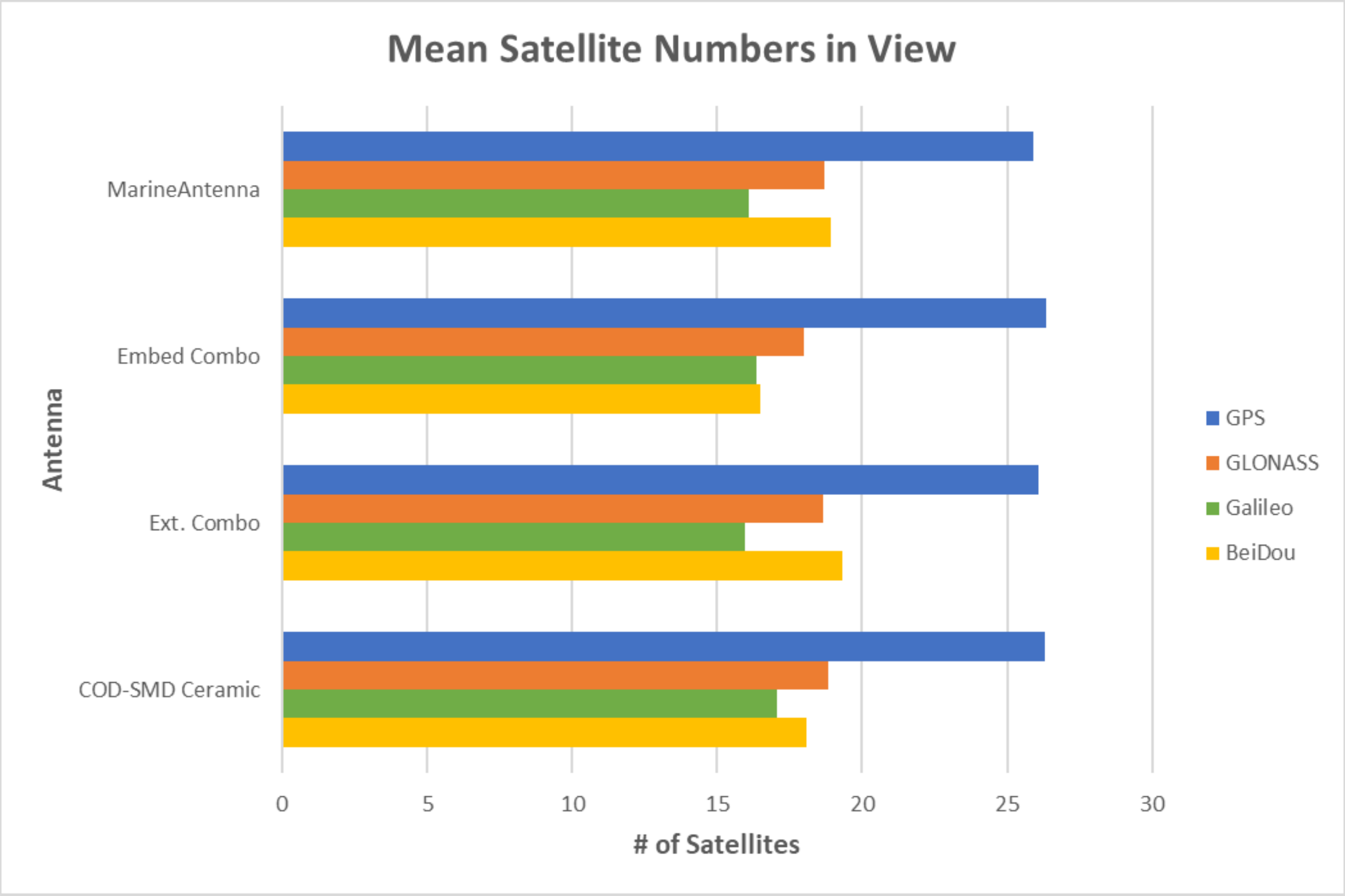


Neptune Project – Key Performance Metrics Measured

Key Performance Metrics	Description
Mean Number of Satellites in View	This metric shows the average number of satellites viewed per test duration for each product tested.
% of satellites with C/N0 > 40dB-Hz	The metric represents the percentage number of satellites that achieved a C/N0 figure greater than 40dB-Hz.
Mean 2DRMS	This metric represents the location accuracy of each of the products. This is a PPP-RTK correction service.
Mean % of Time in Fix/Float Mode for correction measurements	This metric highlights the percentage of time spent in RTK Fix or RTK Float Mode for evaluating the positional accuracy. RTK Float means the positional accuracy has not been resolved by the algorithm in the receiver. RTK Fixed means the receiver has calculated a correct solution.
Mean Time To First Fix	This metric highlights the average Time To First Fix (TTFF). TTFF is the time it takes the system to determine its first positional fix.
Mean number of satellites above/below 30° elevation	This metric represents the mean number of satellites each antenna can see above and below 30° elevation. This is a useful metric to understand how well the antenna can track the satellite as it moves across the sky.



Neptune Project – Field Test Results

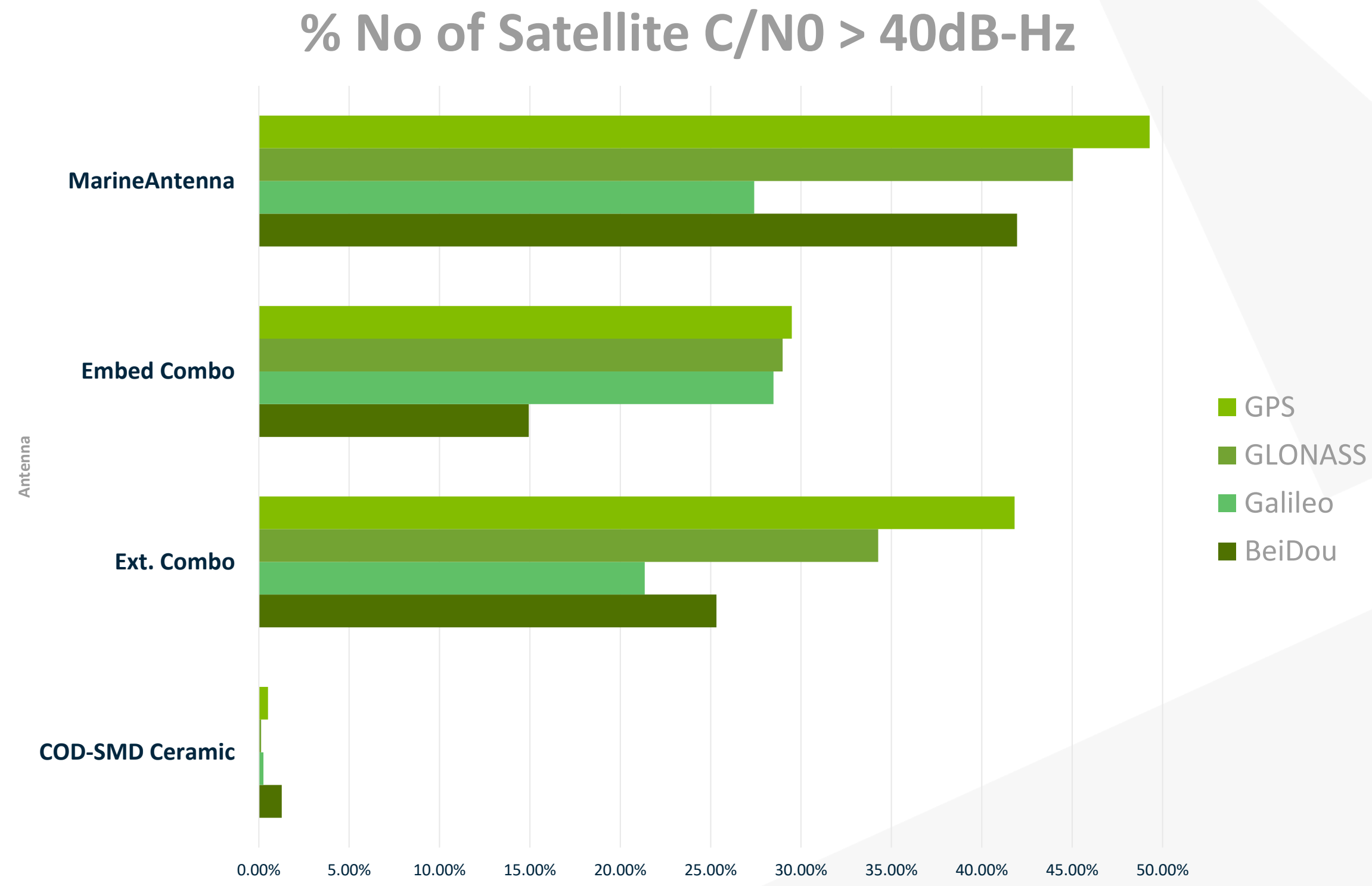


	Mean Satellite Numbers in View			
	GPS	GLONASS	Galileo	BeiDou
COD-SMD Ceramic	26.3	18.83333	17.06667	18.1
Ext. Combo	26.06667	18.63333	15.96667	19.3
Embed Combo	26.33333	18	16.36667	16.5
MarineAntenna	25.9	18.7	16.1	18.93333

The bar chart demonstrates antenna performance by constellation. It displays the average number of satellites viewed per test duration for each product tested.



Neptune Project – Field Test Results

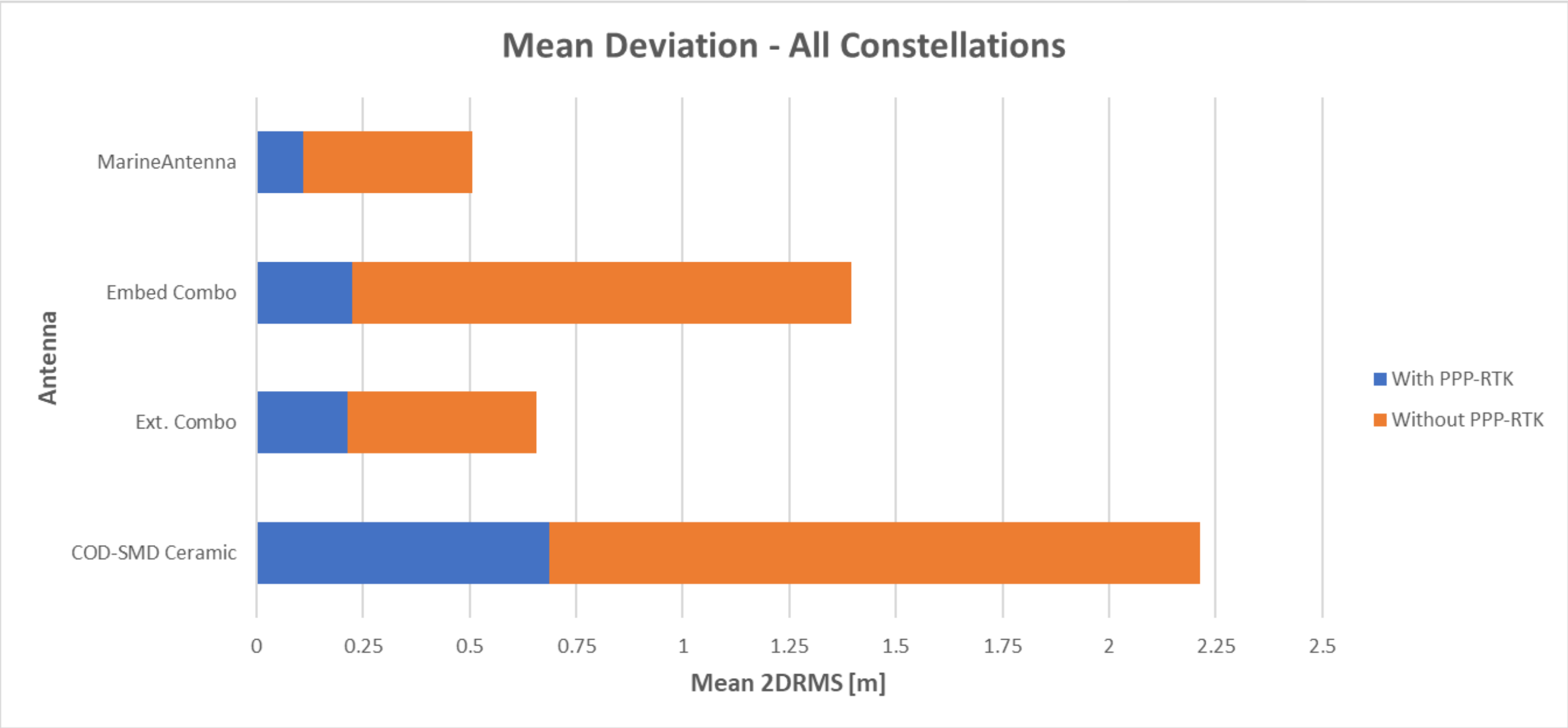


	% No of Satellite C/No > 40dB-Hz			
	GPS	GLONASS	Galileo	BeiDou
COD-SMD Ceramic	0.51%	0.13%	0.25%	1.27%
Ext. Combo	41.82%	34.27%	21.36%	25.32%
Embed Combo	29.49%	28.99%	28.48%	14.94%
MarineAntenna	49.29%	45.05%	27.41%	41.96%

The bar chart represents the percentage number of satellites that achieved a C/N0 figure greater than 40dB-Hz. It is also further broken down by constellation. The C/N0 value is a good indication of signal quality in a GNSS system.



Neptune Project – Field Test Results

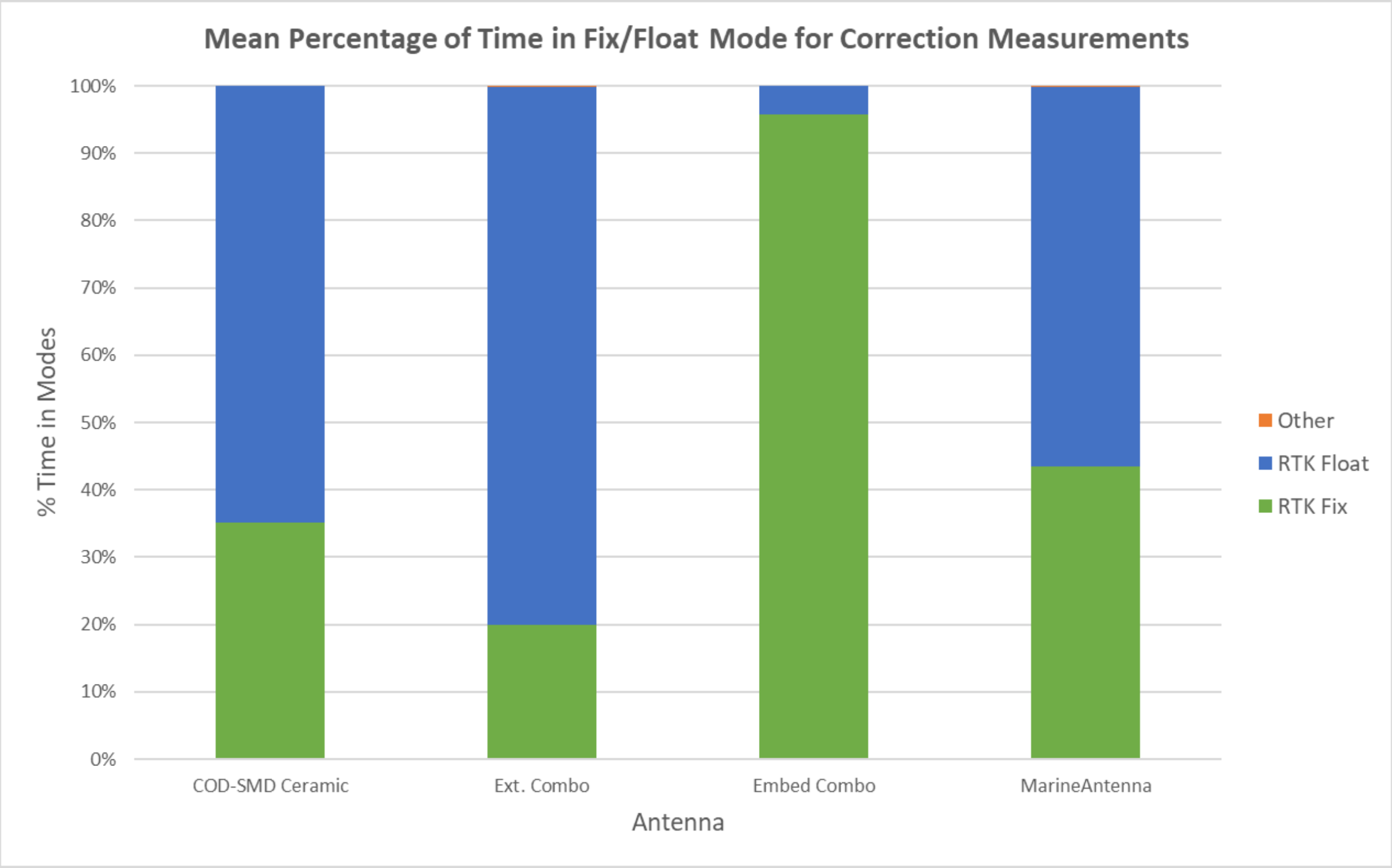


	Mean Deviation - All Constellations [m]	
	With PPP-RTK	Without PPP-RTK
COD-SMD Ceramic	0.686387	2.21432
Ext. Combo	0.21232	0.656947
Embed Combo	0.223213	1.39554
MarineAntenna	0.10954	0.50742

The bar chart represents the location accuracy of each of the products. This is a PPP-RTK correction service.



Neptune Project – Field Test Results

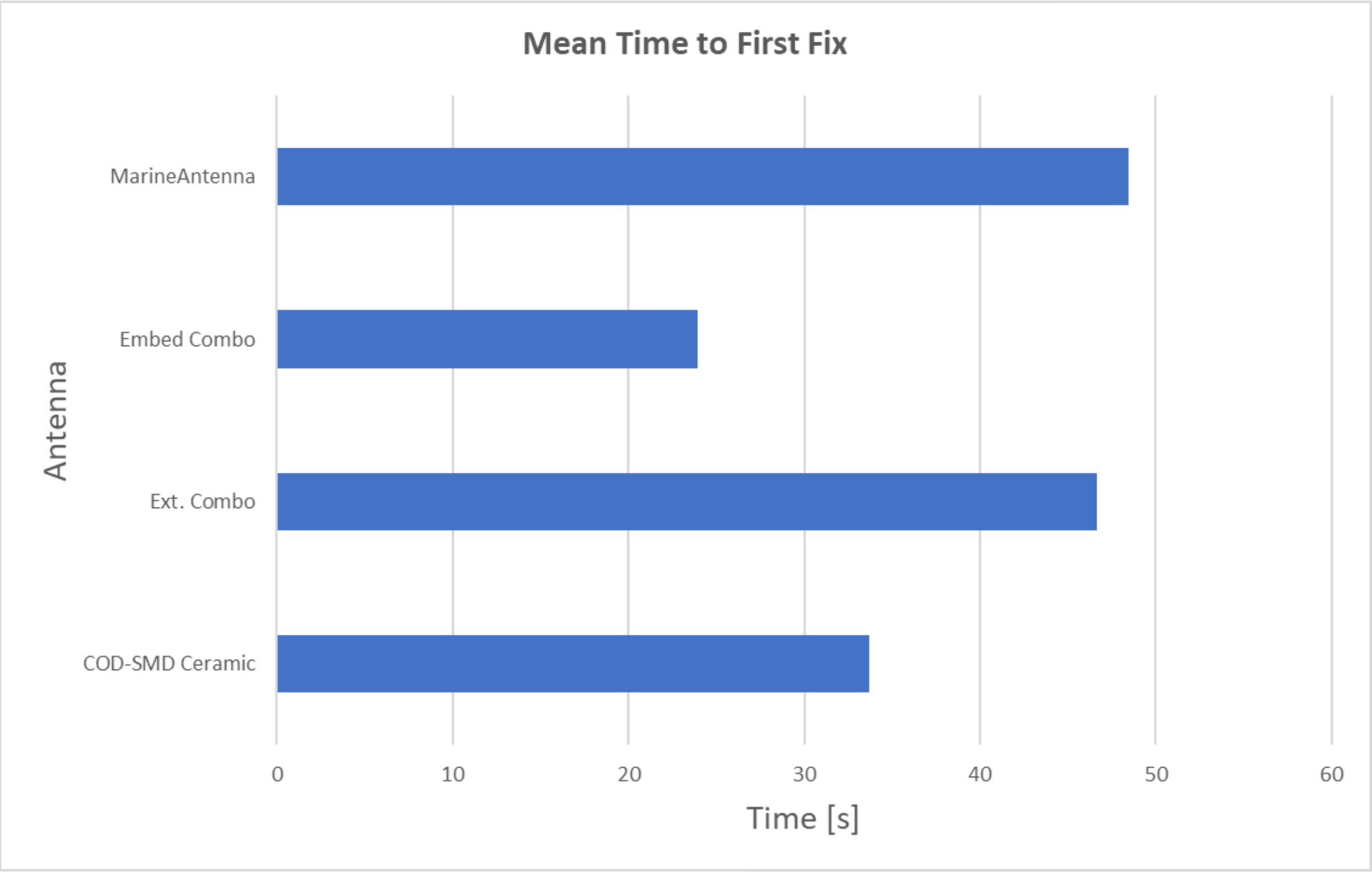


	Mean Percentage of Time in Fix/Float Mode for Correction Measurements		
	RTK Fix	RTK Float	Other
COD-SMD Ceramic	35%	65%	0%
Ext. Combo	20%	80%	0%
Embed Combo	96%	4%	0%
MarineAntenna	44%	56%	0%

The bar chart below highlights the percentage of time spent in RTK Fix or RTK Float Mode for evaluating the positional accuracy. RTK Float means the positional accuracy has not been resolved by the algorithm in the receiver. RTK Fixed means the receiver has calculated a correct solution.



Neptune Project – Field Test Results

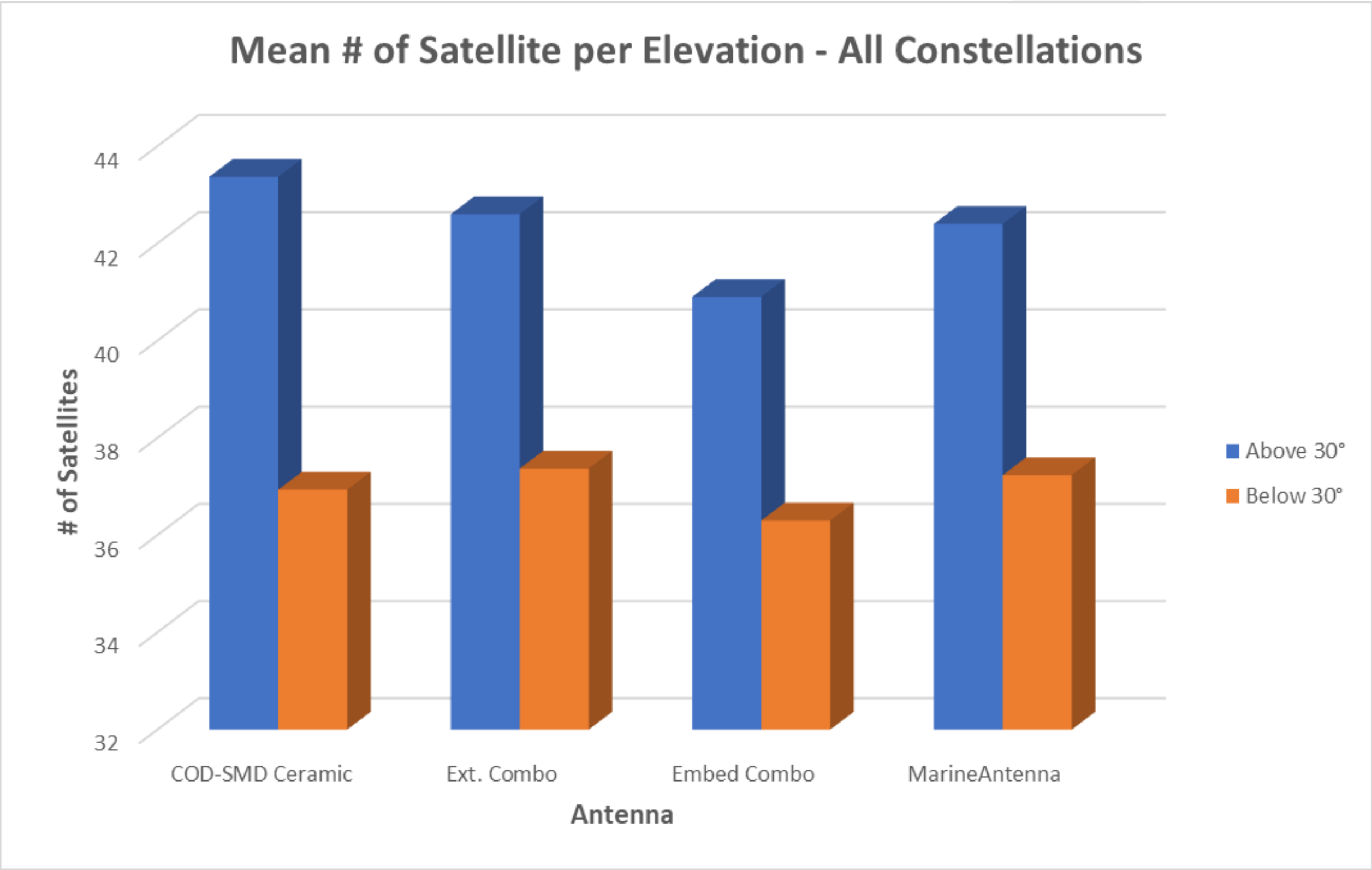


	Mean Time to First Fix		
	Mean TTFF		# Measurements
COD-SMD Ceramic	33.7037		27
Ext. Combo	46.68		25
Embed Combo	23.96667		30
MarineAntenna	48.48		25

The bar chart below highlights the average Time To First Fix (TTFF). TTFF is the time it takes the system to determine its first positional fix. Typically, it occurs between 20-40 seconds but can be influenced by the sky and weather conditions



Neptune Project – Field Test Results

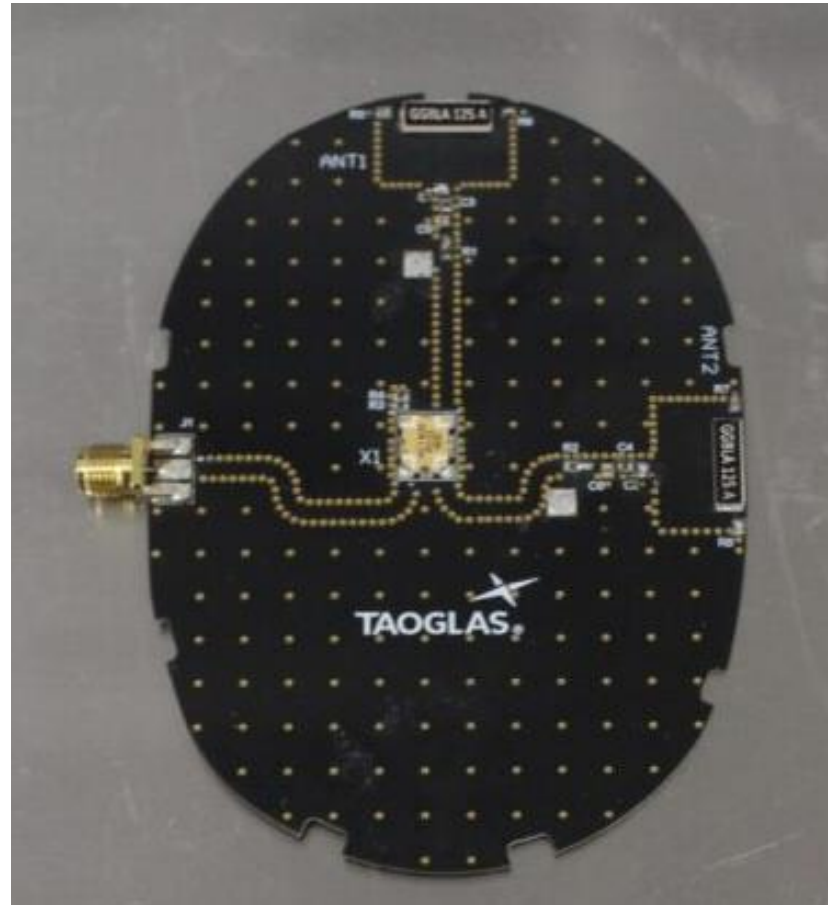


	Mean # of Satellite Visibility - All Constellations	
	Above 30°	Below 30°
COD-SMD Ceramic	43.36667	36.93333
Ext. Combo	42.6	37.36667
Embed Combo	40.9	36.3
MarineAntenna	42.4	37.23333

The bar chart below displays the mean number of satellites each antenna can see above and below 30° elevation. This is a useful metric to understand how well the antenna can track the satellite as it moves across the sky.



Neptune Project - Conclusions



Product 1 - Compact omni-directional GNSS multiband SMD Ceramic antenna (COD-SMD Ceramic)

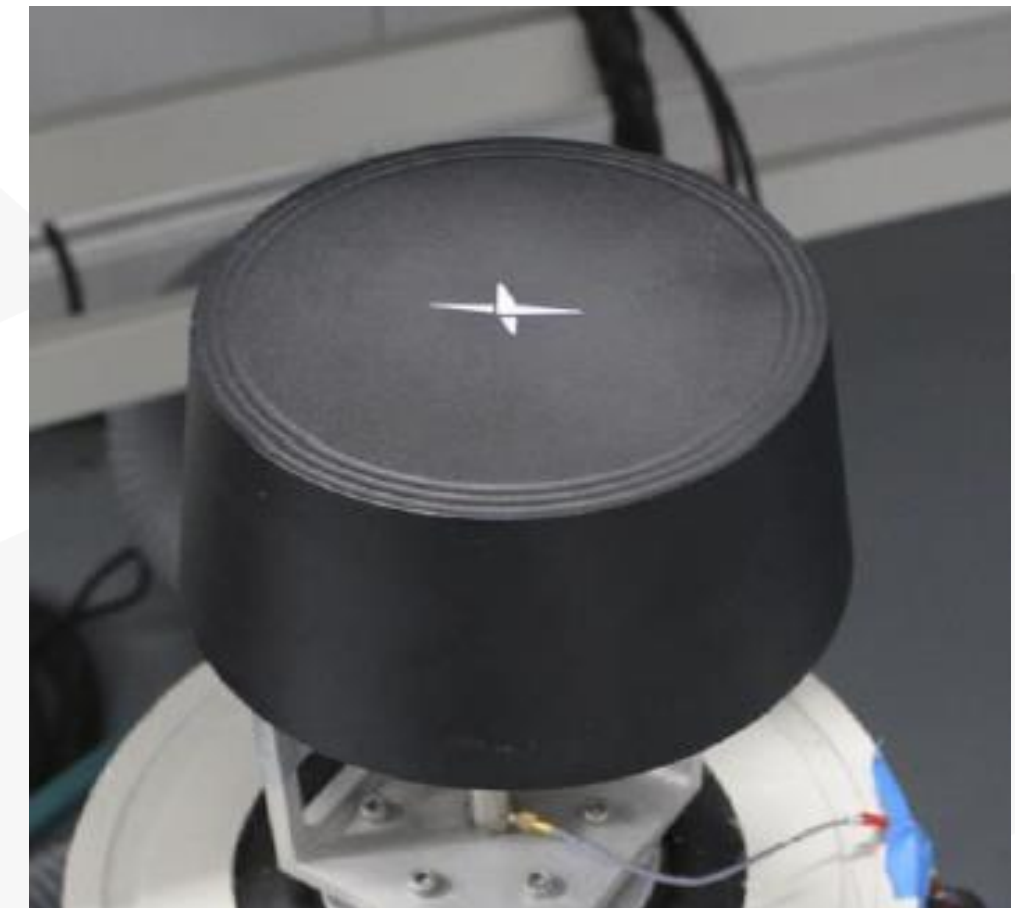
- The C/N0 value of this product when it acquired satellites did not hit the target value of 40dB-Hz often.
- The application of the LNA improved the C/N0 values.
- Further study and effort is needed with this product to improve its performance.



Neptune Project - Conclusions

Product 2 - External Combination Antenna with Multiband GNSS Antenna Solution (Ext. Combo)

- The mean 2DRMS value without correction was 0.65m and with correction was 0.21m.
- It was the 2nd highest in terms of C/N0 value above 40 dB-Hz.



Neptune Project - Conclusions



Product 3 – Embedded Multiband GNSS with WiFi/ISM Technology (Embed Combo)

- Mean deviation of 1.39m without correction, however it achieved 0.22m with PPP-RTK correction services applied.
- On average the percentage of satellites above 40dB-Hz was 25% with this antenna.
- This antenna achieved the quickest TTFF at 24secs.



Neptune Project - Conclusions

Product 4 – Multiband GNSS antenna for Marine Application (Marine Antenna)

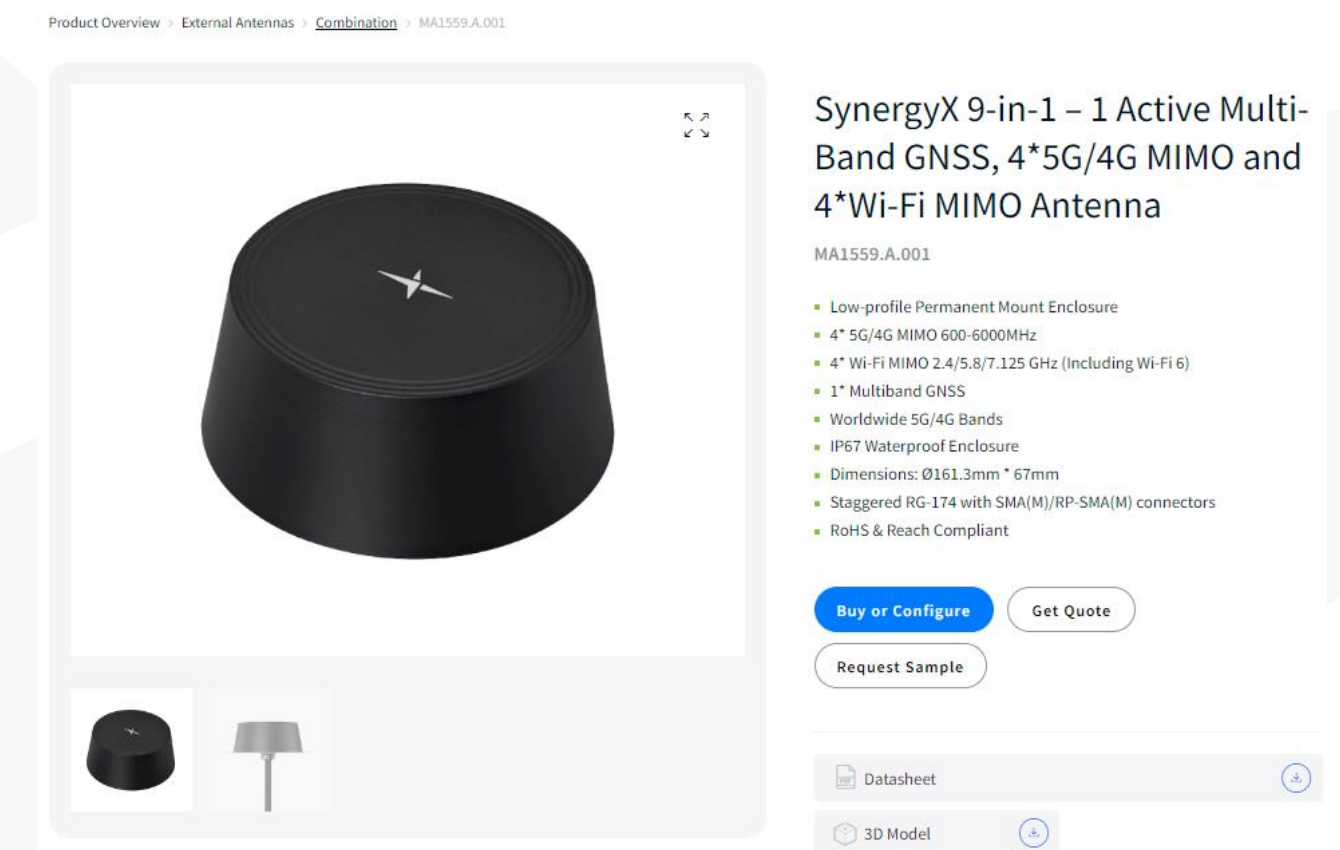
- Best out of the 4 products tested.
- Accuracy of 0.5m without correction services applied and 0.1m when PPP-RTK services were used.
- On average the percentage of satellites above 40dB-Hz was 40% with this antenna, this was the highest achieved out of the 4 products tested.



Neptune Project – Future Growth

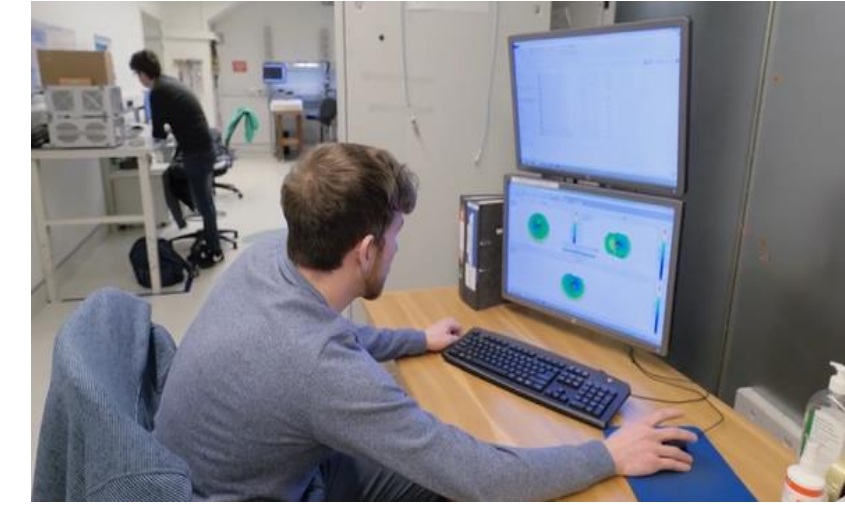
Product on the Market

- External Combination Antenna is already on our website
- A modified variant of the embedded solution is being produced for a customer
- Marine Antenna will be available shortly.



Neptune Project – Benefits of working with ESA

- Extend and expedite our own research and development
- Enables shared learning with other companies
- Learning Growth
- Hiring staff





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You

www.taoglas.com

