New 3D Icosahedron grid for OTA antenna measurement

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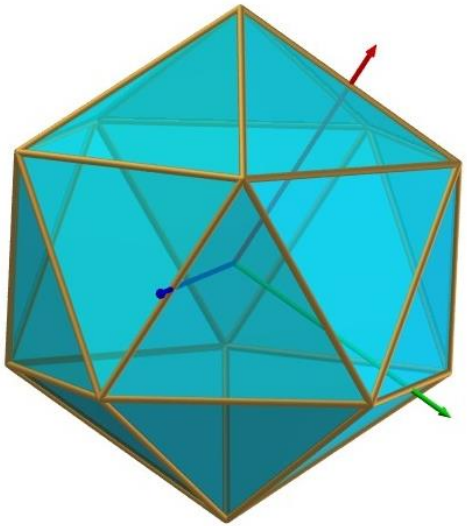
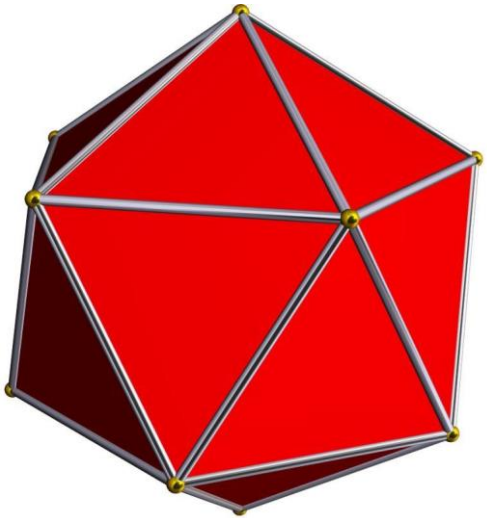
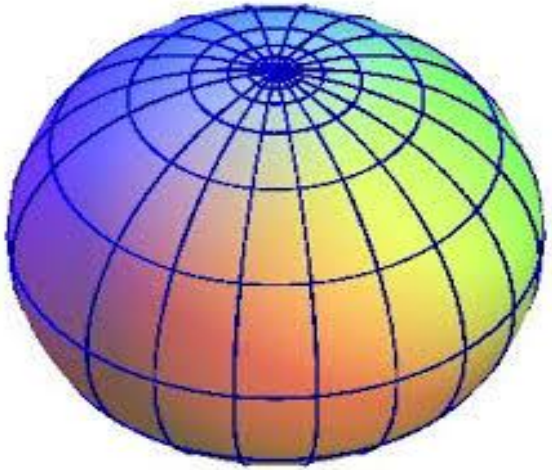


New OTA method grid proposal



Versus



Icosahedron

Sphere

Context

Measurement of Total radiated power (TRP) needs device under to emit permanently at maximum power . However, for an IoT product and small product sizes, it could be difficult to perform at one time the TRP measurement with the same battery life. Thus, a quicker method is required for such product

Furthermore, IoT needs leverage of cost therefore it is important to avoid the same tests protocol as a smartphone

This new grid OTA test method is proposed in order to reduce the time consumption of testing with similar test results as the traditional method

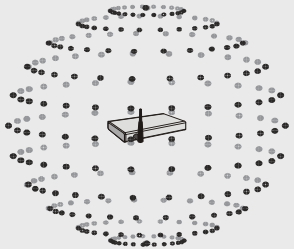
Moreover, for smartphone, a trend of increasing of supported frequency bands on devices is observed and which leads to lot of measurements on devices for OTA antenna with high cost of testing therefore the icosahedron test grid could be adopted by the industry for smartphone testing

The Proposal method could help to : Reduce the **time consumption** and **cost** for OTA testing

Background

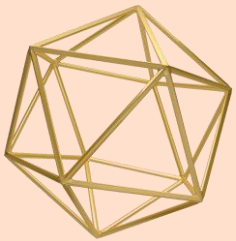
In standards (3GPP + CTIA) it is defined a spherical method grid based on 30° or 15 ° step angles

Therefore a traditional method is executed with <u>72 or 288 measurement points</u>

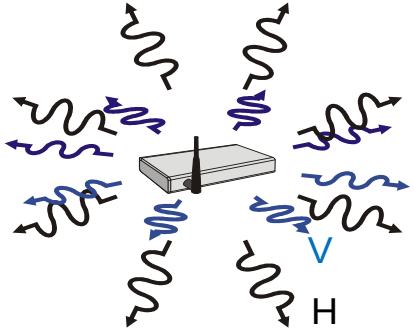


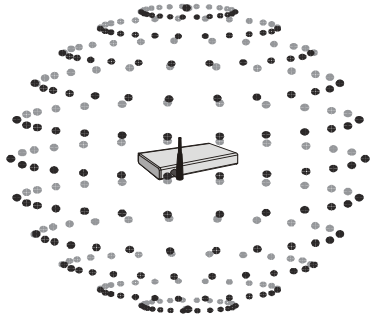
The **Icosahedron** is one of the platonic solids, it has 20 faces of equilateral triangle and 12 vertices as shown in the pictures below

The **icosahedron 3D grid method** presented in this document consists to measure at each of the 12 vertices which lead to **<u>12 points of measurements</u>**

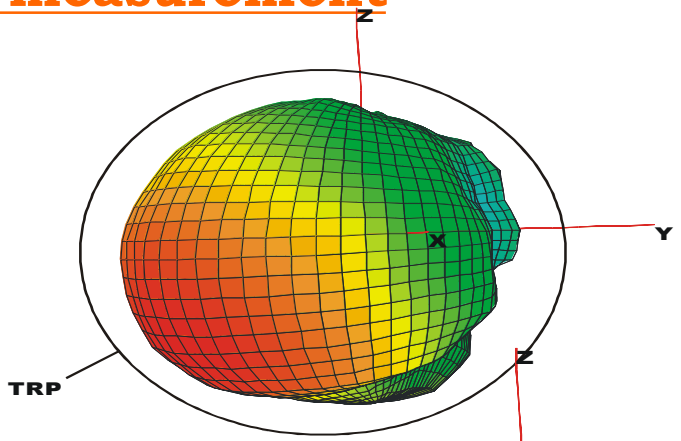


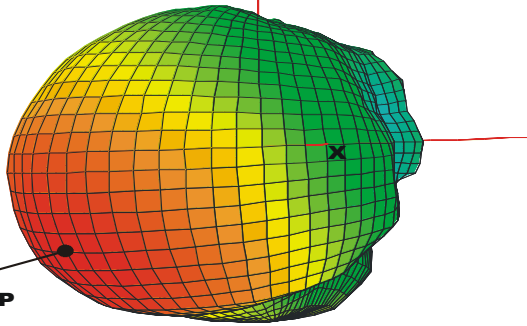
Example of Traditional Radiated Power measurement



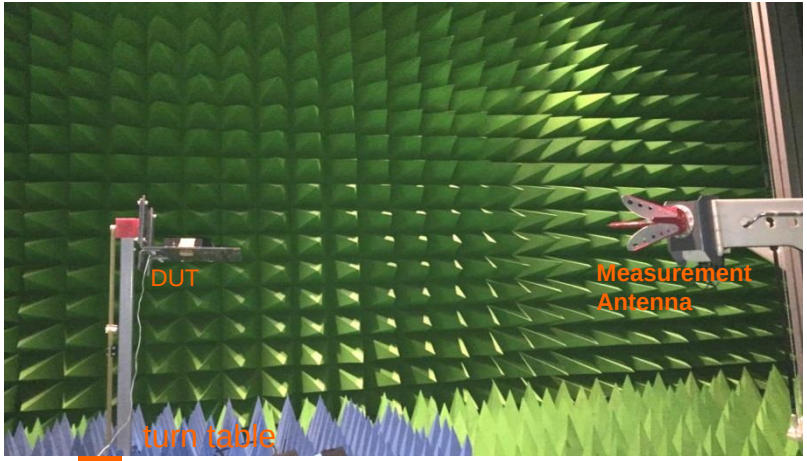


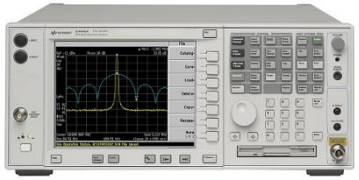
Measurement grid





Orange Full Anechoic Chamber

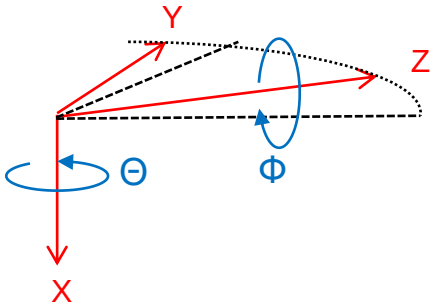


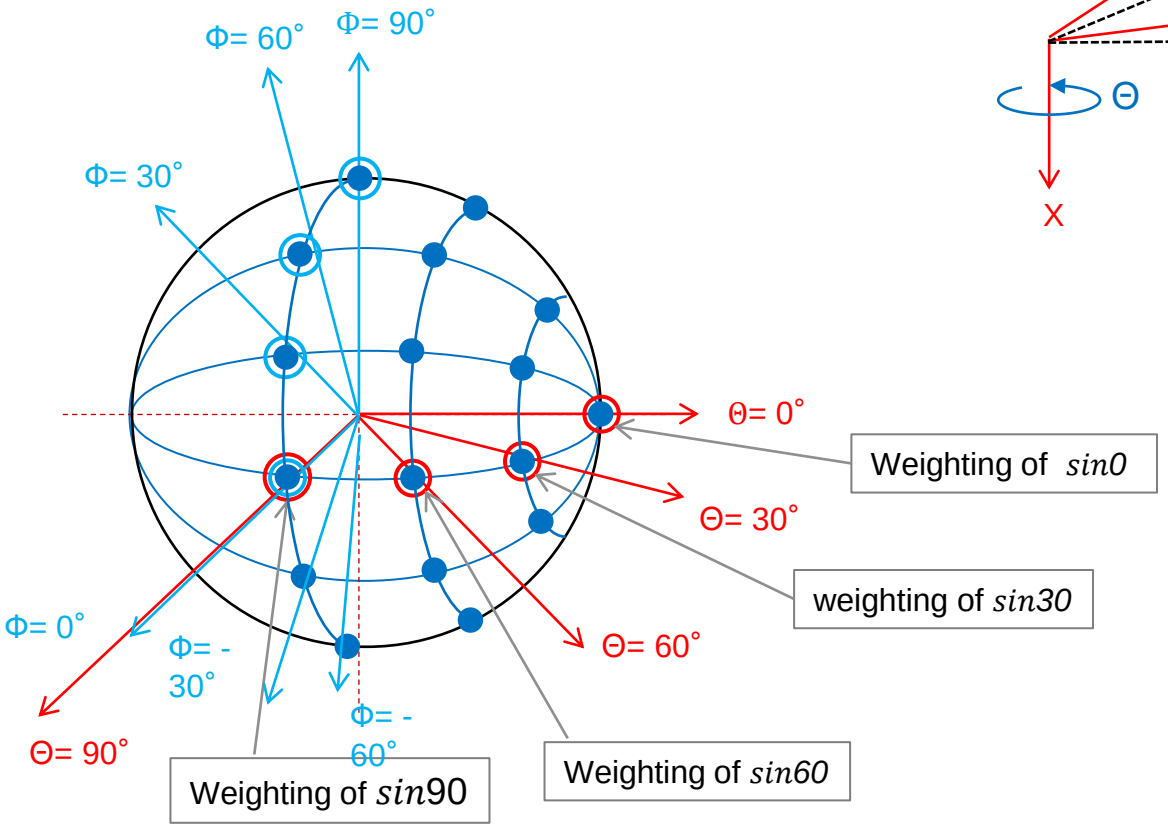


spectrum analyser

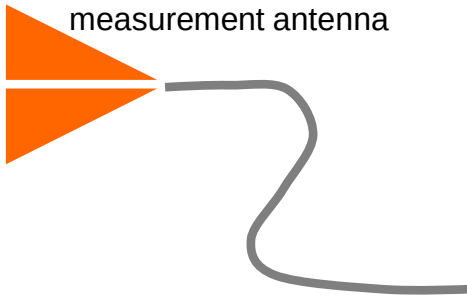
TRP Measurement with spherical grid and power weighting

Weighting of power (EIRP) with $sin\theta$





Dual polar
measurement antenna



Calculation of Total Radiated power with traditional 3D grid

$$TRP \cong \frac{\pi}{2NM} \sum_{i=1}^{N-1} \sum_{j=0}^{M-1} \left[EiRP_{\theta}(\theta_i, \phi_j) + EiRP_{\phi}(\theta_i, \phi_j) \right] \sin(\theta_i)$$

288 points measurements with 15 ° step

$$TIS \cong \frac{2NM}{\pi \sum_{i=1}^{N-1} \sum_{j=0}^{M-1} \left[\frac{1}{EIS_{\theta}(\theta_i, \phi_j)} + \frac{1}{EIS_{\phi}(\theta_i, \phi_j)} \right] \sin(\theta_i)}$$

72 points measurements with 30 ° step

3D Icosahedron grid

Description of the test method (Icosahedron)

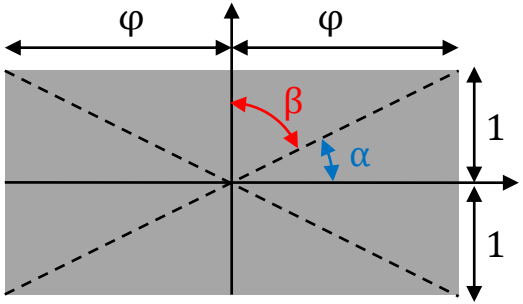
The device is rotated to describe an icosahedron 3D diagram and at each vertices of the icosahedron a power is measure for horizontal et vertical polarizations

The coordinates of the 12 vertices have been determined before hand , therefore the automation system can move the device towards those points following angles indicated

Icosahedron grid method is applicable for both TRP and TRS measurements

Spherical coordinates of Icosahedron grid :Mathematics behind

Golden number $\varphi = \frac{1+\sqrt{5}}{2}$

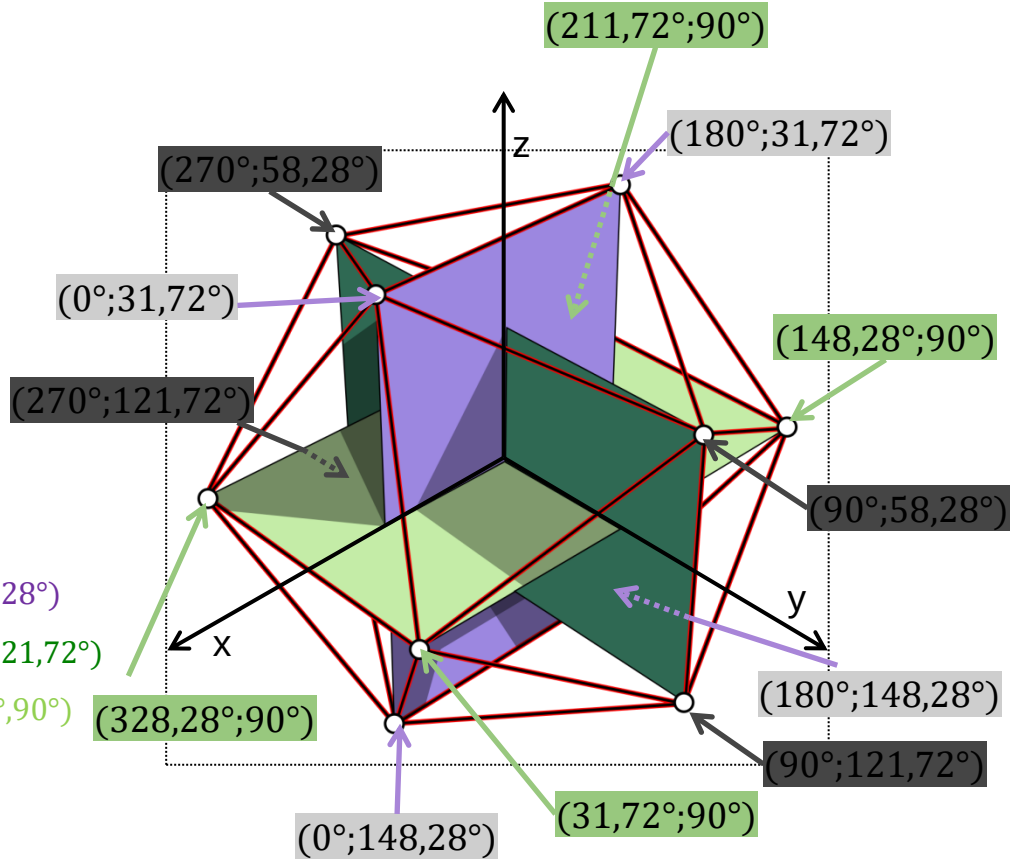


$$\tan\alpha = \frac{1}{\varphi}$$

$$\alpha = 31{,}72°$$

$$\tan\beta = \frac{\varphi}{1}$$

$$\beta = 58{,}28°$$



(Z,X) plan➔ (180°;31,72 °), (0°,31,72°), (0°,148,28°), (180°,148,28°)

(Z,Y) Plan ➔ (270°;58,28 °), (90°,58,28°), (90°,121,72°), (270°,121,72°)

(X,Y) Plan➔ (31,72°;90°), (148,28°;90°), (211,72°,90°), (328,28°,90°)

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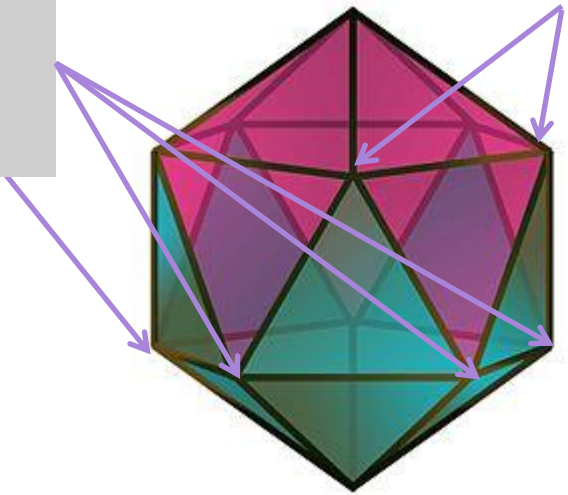
Coordinates of the grid in same axis system as traditional grid

(0°;0°)

(36°; 116,56° « 180 - 63,44° »)
(108°; 116,56°)
(180°; 116,56°)
(252°; 116,56°)
(324°; 116,56°)

(0°; 63,44° « 2x31,72° »)
(72°;63,44°)
(144°;63,44°)
(216°;63,44°)
(288°;63,44°)



(0°;180°)

Calculation of TRP and TRS with Icosahedron grid

With Icosahedron grid system, all vertices have the same weight, therefore no need to have a complicated formula but a simple average is enough!

A total of the 12 vertices leads to an linear average of 12 measurements as below

$$TRP_{Icosaèdre} \approx \frac{1}{12} \sum_{s=0}^{11} \left(EIRP_{\theta}(\theta_s) + EIRP_{\Phi}(S_S) \right)$$

12 points measurements

$$TRS_{Ico} \approx \frac{12}{\sum_{i=0}^{11} \left(1/EIS_{\theta}(\theta i. \Phi i) + 1/EIS_{\Phi}(\theta i. \Phi i) \right)}$$

12 points measurements

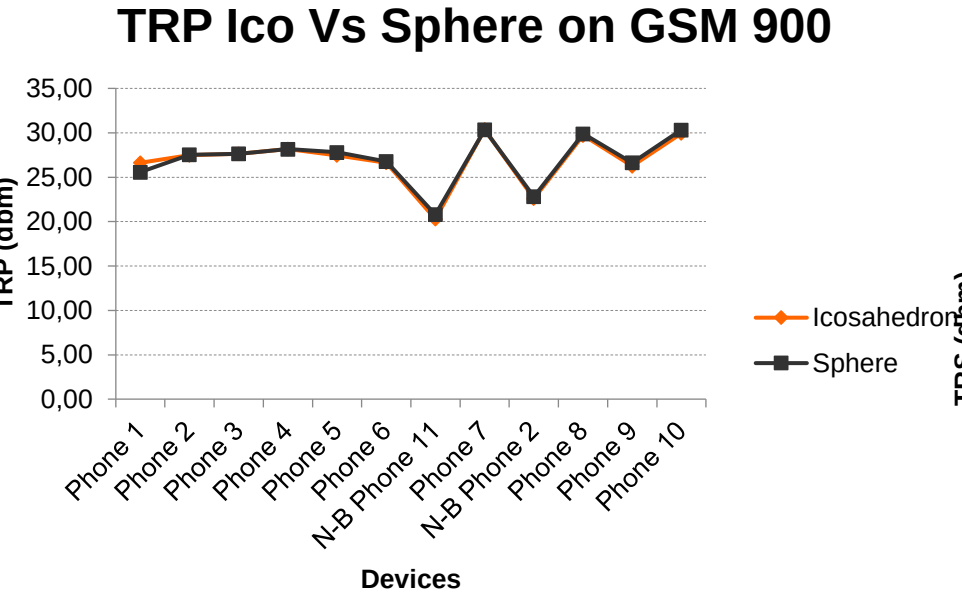
Testing Results

And comparison

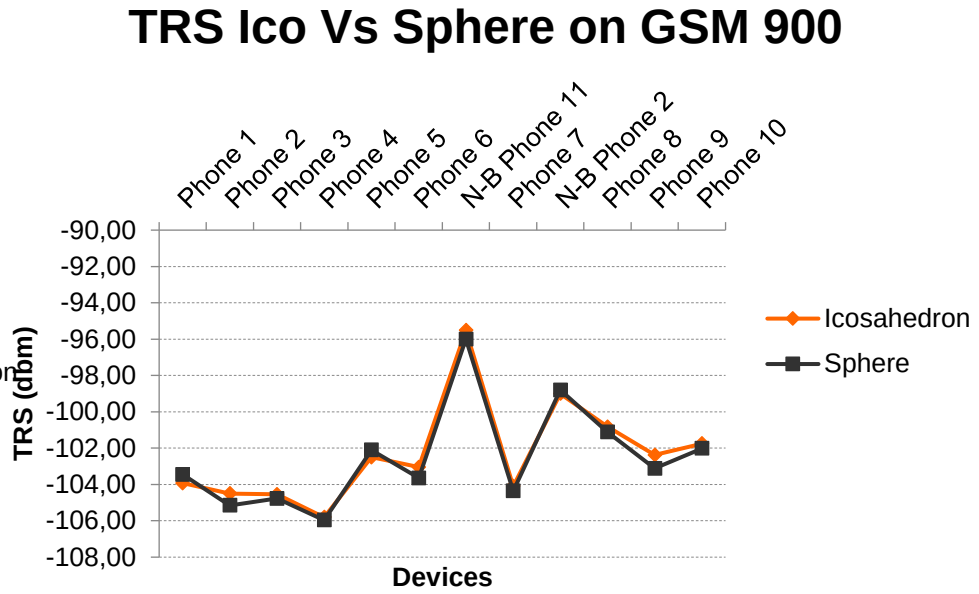
Devices from different brands have been chosen for test comparison: Sony, Samsung, Blackberry, HTC, Huawei, Apple, LG, and 2 non branded devices have been tested

The target is to verify correlation regardless of performances of the device models

GSM 900 : New (Icosahedron) and Traditional (spherical)



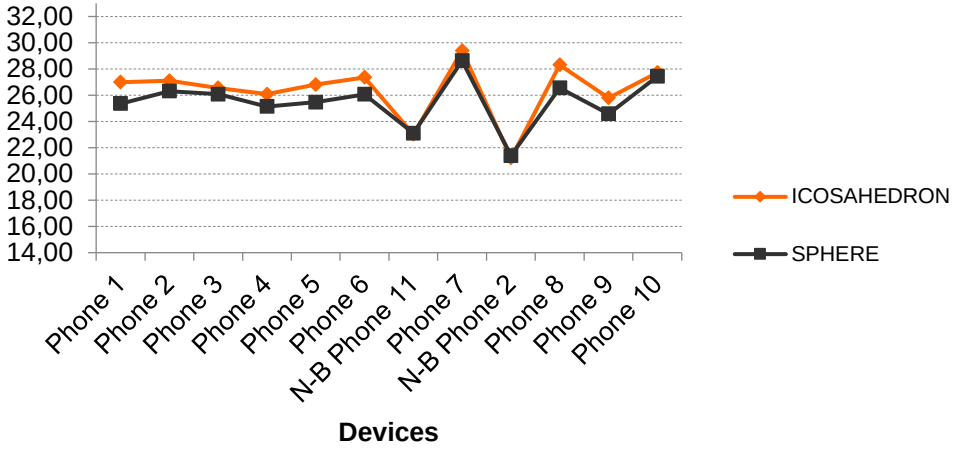
Correlation=99%



Correlation=99%

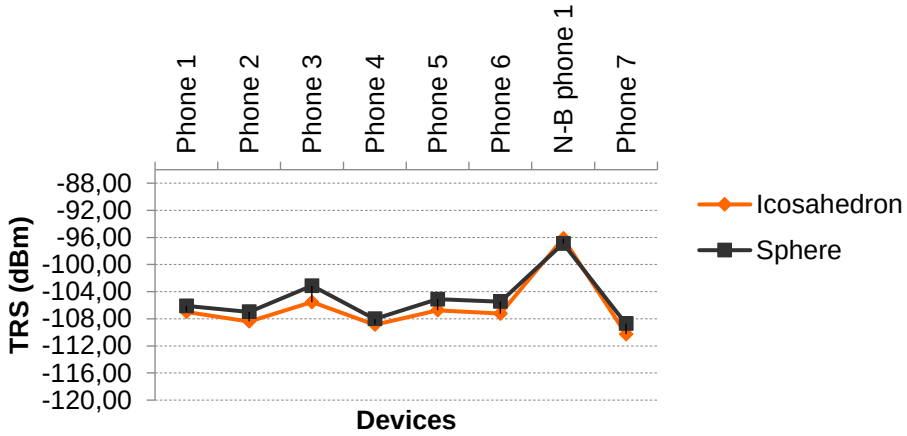
GSM 1800 : New (Icosahedron) and Traditional (spherical)

TRP Ico Vs Sphere on DCS 1800



Correlation=97%

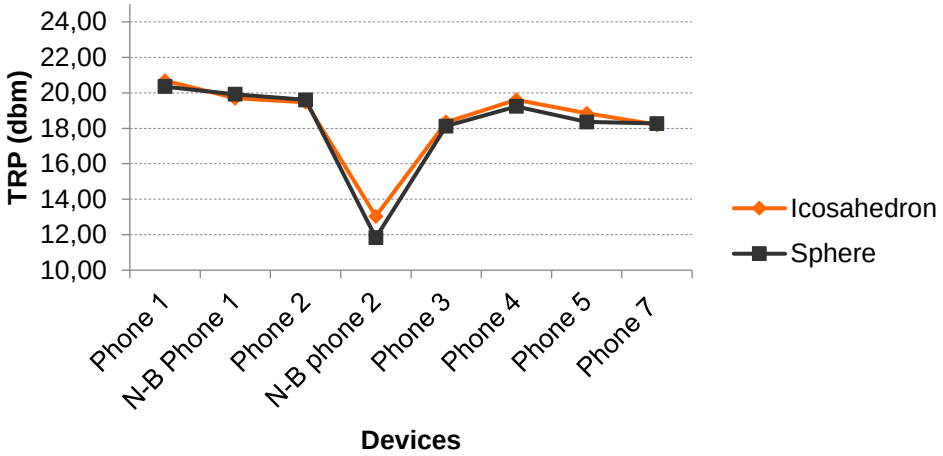
TRS Ico vs Sphere on DCS 1800



Correlation=98%

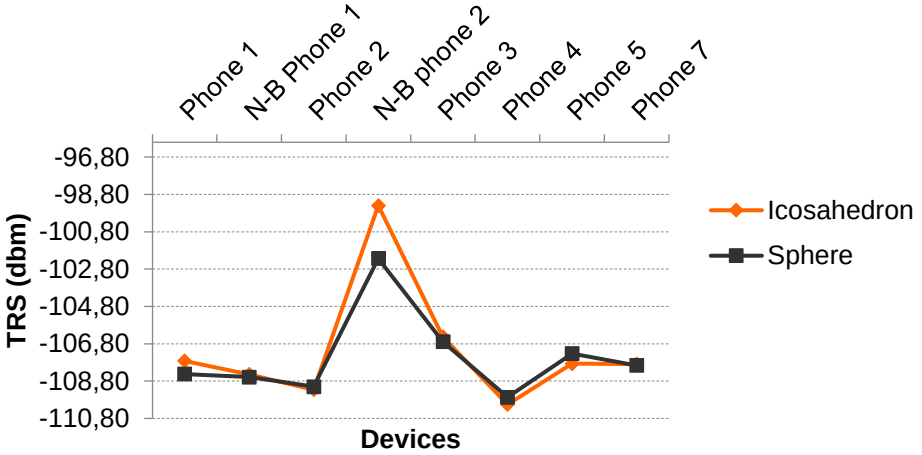
UMTS FDD 8 : New (Icosahedron) and Traditional (spherical)

TRP Ico Vs Sphere on FDDVIII



Correlation=99%

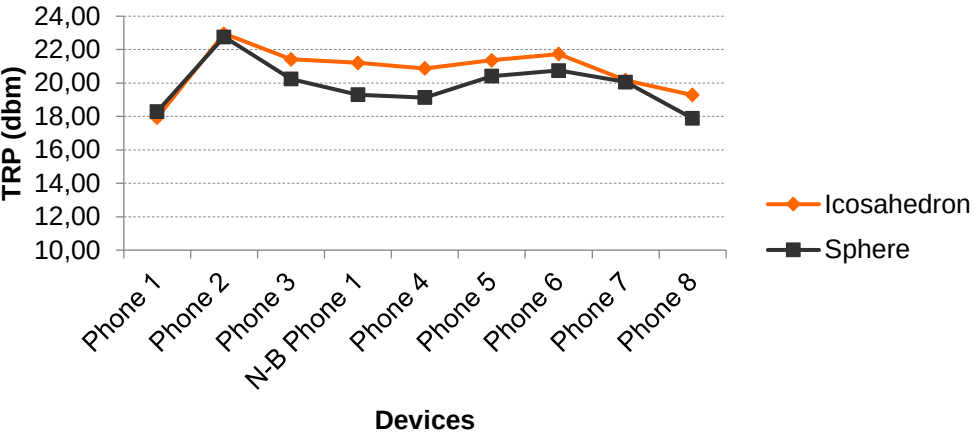
TRS Ico Vs Sphere on FDDVIII



correlation=92%

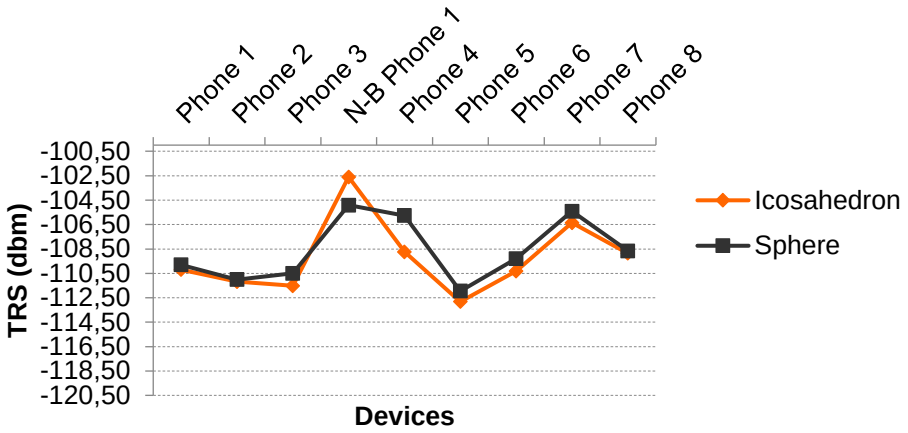
UMTS FDD 1 : New (Icosahedron) and Traditional (spherical)

TRP Ico Vs Sphere on FDDI

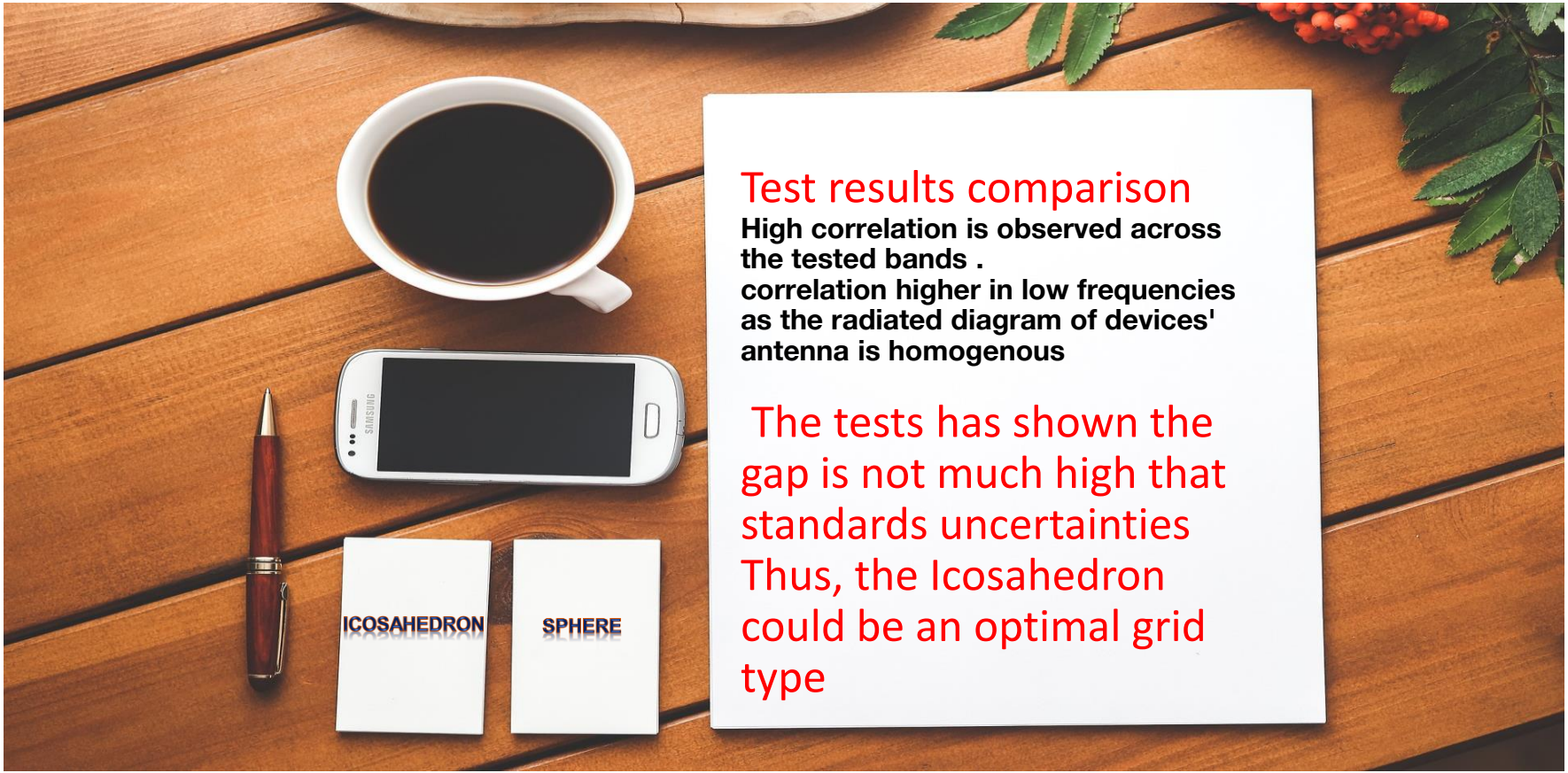


Correlation =90%

TRS Ico Vs Sphere on FDDI



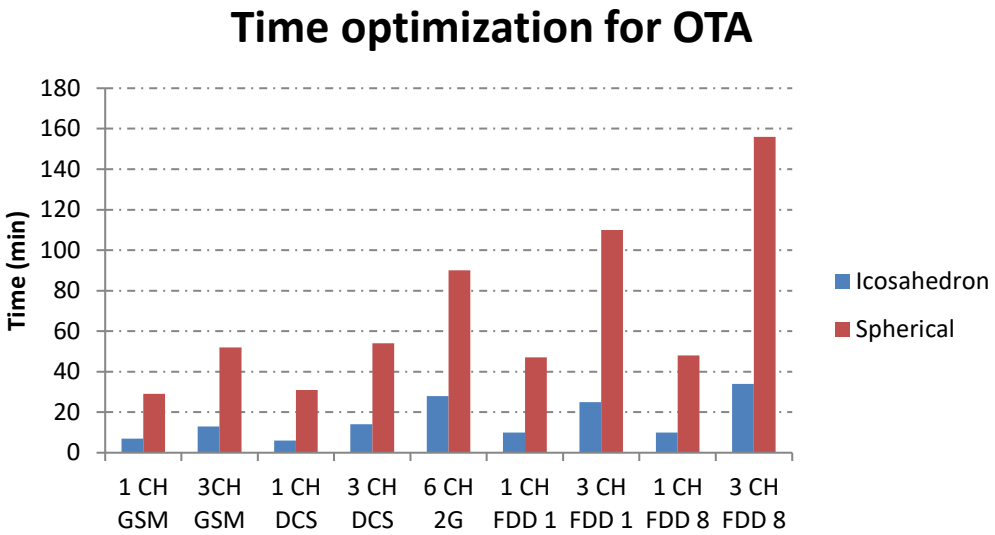
correlation = 90%


Test results comparison
High correlation is observed across the tested bands .
correlation higher in low frequencies as the radiated diagram of devices' antenna is homogenous
The tests has shown the gap is not much high that standards uncertainties Thus, the Icosahedron could be an optimal grid type
ICOSAHEDRON
SPHERE
SAMSUNG

Time duration of each measurement method (Icosahedron and Spherical)

Time duration of campaign

	Number of channels	3D Icosahedron (min)	3D Traditional (min)
GSM 900	1	7	29
	3	13	52
GSM 1800 (DCS)	1	6	31
	3	14	54
Full Campaign 2G (GSM + DCS)	6	28	90
3G FDD 1	1	10	47
	3	25	110
3G FDD 8	1	10	48
	3	34	156



Time consumption is divided by 4

Findings

	Icosahedron (min)	Spherical (min)	time reduction factor
1 CH GSM	**7**	**29**	4,1
3CH GSM	**13**	**52**	4,0
1 CH DCS	**6**	**31**	5,2
3 CH DCS	**14**	**54**	3,9
6 CH 2G	**28**	**90**	3,2
1 CH FDD 1	**10**	**47**	4,7
3 CH FDD 1	**25**	**110**	4,4
1 CH FDD 8	**10**	**48**	4,8
3 CH FDD 8	**34**	**156**	4,6

When using Icosahedron method the time cost can be reduced by 4.

and an excellent correlation has been found between Icosahedron measurement and Spherical (traditional) method

Conclusion

This optimized method is proposed firstly for IoT devices and small size devices in order to save time and cost during testing campaign

But It could be adopted for smartphones testing in low frequency bands Such as GSM bands , UMTS FDD 8, LTE band 28, LTE band 20, LTE band 8 Etc…

Thank you!

Should you have any question feel free to contact momar.goumballe@orange.com