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Galileo Reference Antenna Pattern

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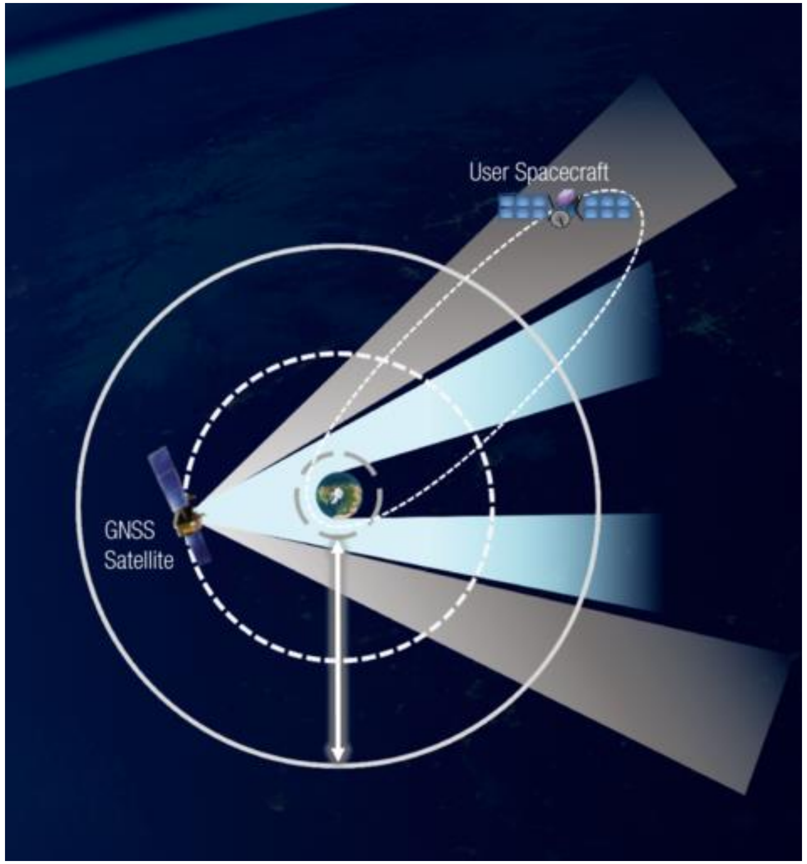
Presentation Highlight

- Background
- Model Assumptions
- Multi-step 3D Reconstruction Procedure
- Results examples
- Galileo pattern driven Space Service Volume Link Budget analysis
- Conclusions

Background

- The Galileo Programme is deriving a *"**Galileo Reference Antenna Pattern**"*
- This task responds to the **ICG SSV** (ICG-14, 2019) recommendation of on "GNSS transmit antenna patterns or equivalent representative modelling information, *potential of GNSS for space users*
- Galileo intends to provide the user community with a **representative model.** The derivation is built on measurements performed on all the Galileo FOC satellites antennas

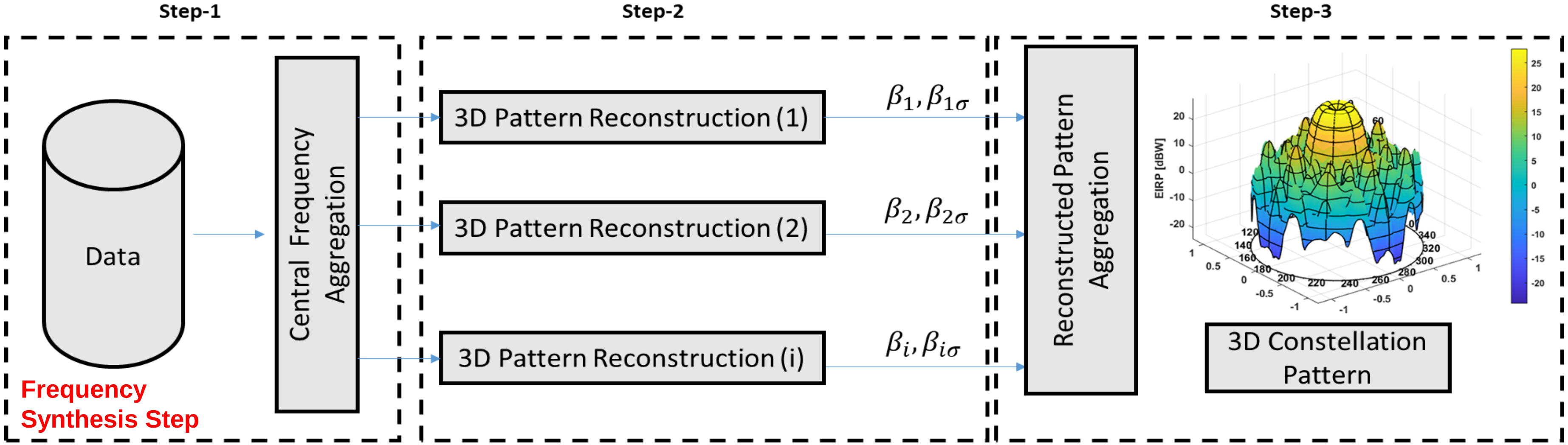


Space Service Volume

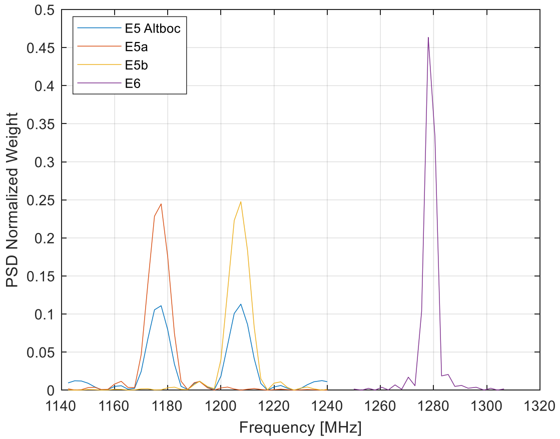
Model Assumptions

- **A 3D antenna radiation pattern reconstruction procedure** derived from antenna's characterization techniques has been considered to mitigate unexpected discontinuities
- Observations have been nested or clustered within different subjects at the bottom level and belonging to the same **Galileo Constellation pattern population** at the top level
- The approach aims at extending the model to a more general representation, which statistically takes into account possible antenna realizations and residual errors through a correspondent **bound estimation**
- Those bounds corresponds to 2sigma (95%) of the expected values and they will be included in the metadata files as **Upper and Lower Bounds**

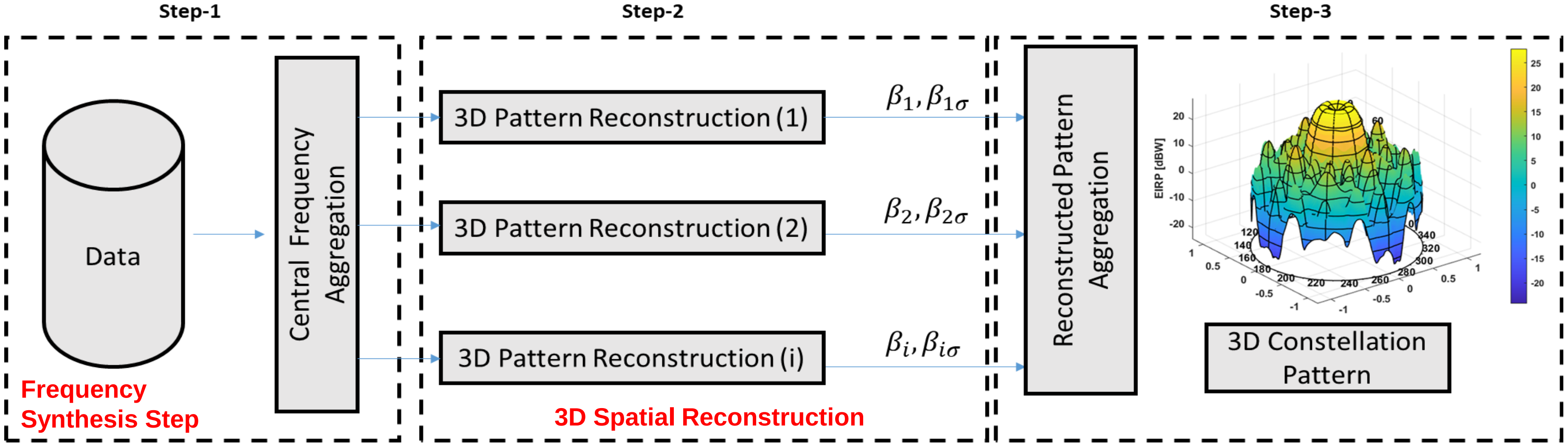
MULTI-STEP 3D RECONSTRUCTION PROCEDURE



$$G_f^i\Big|_{\theta_j,\varphi_k} = \sum_{n=1}^{N} W_{\Delta f_n}^{PSD}\, G(\theta_j, \varphi_k)$$

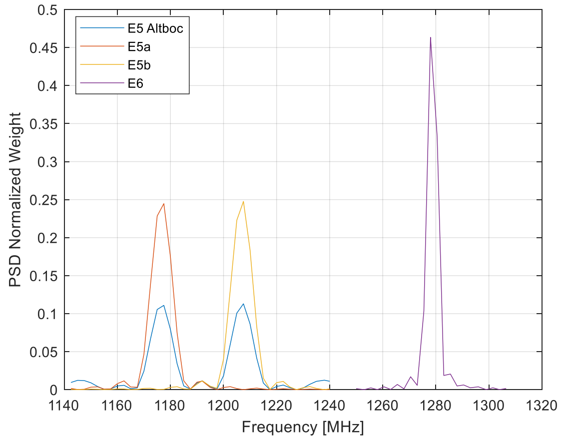


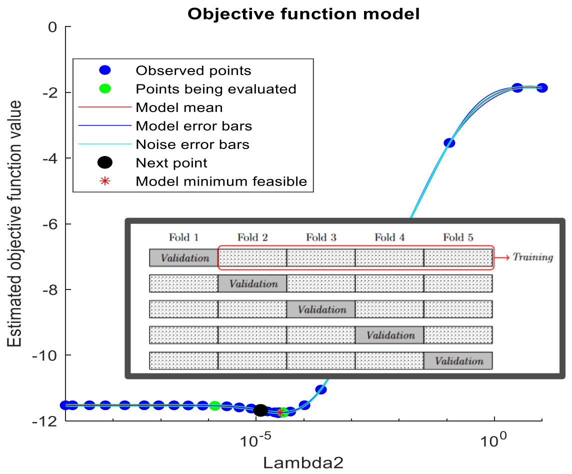
Multi-step 3D Reconstruction Procedure



$$G_f^i\Big|_{\theta_j,\varphi_k} = \sum_{n=1}^{N} W_{\Delta f_n}^{PSD}\, G(\theta_j,\varphi_k)$$

$$SH(\theta,\varphi) = \sum_{l=1}^{n}\sum_{m=-l}^{l} Y_{lm}(\theta,\varphi)\beta_{lm}$$





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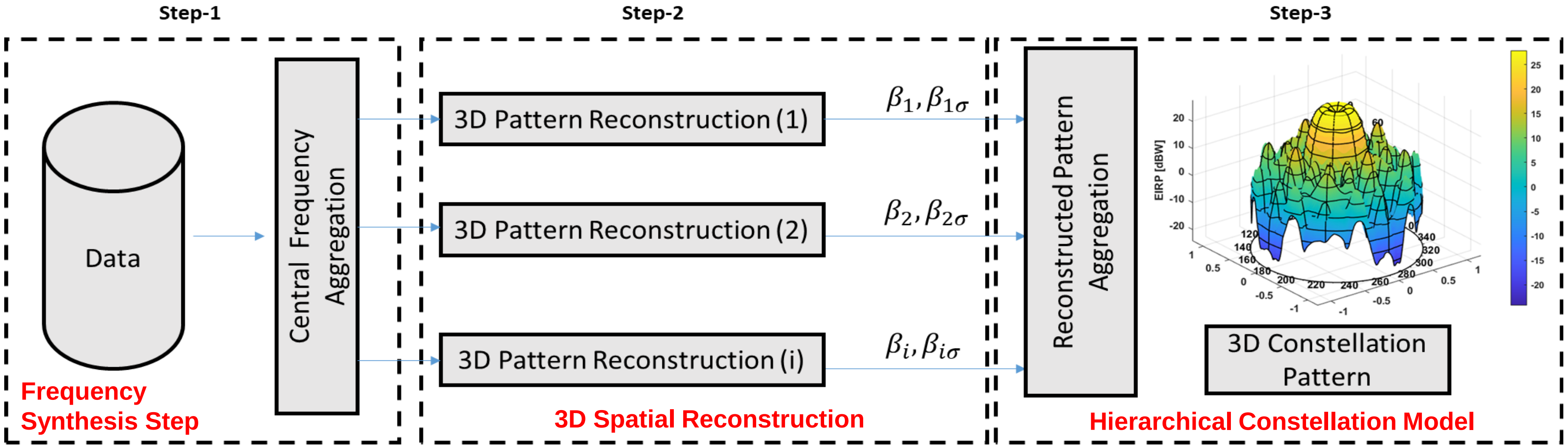
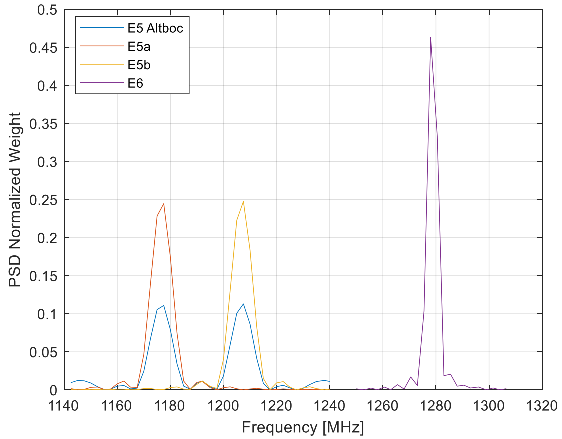
Multi-step 3D Reconstruction Procedure

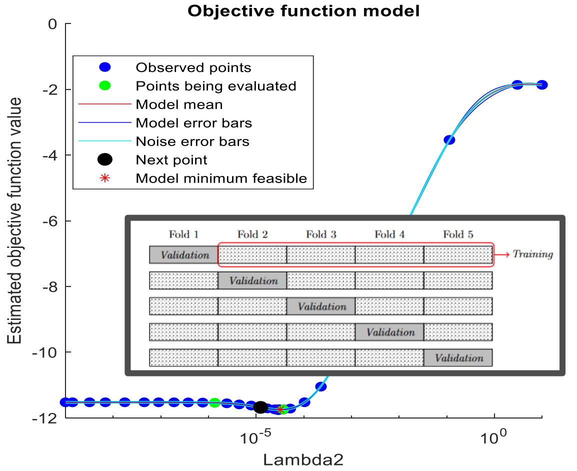


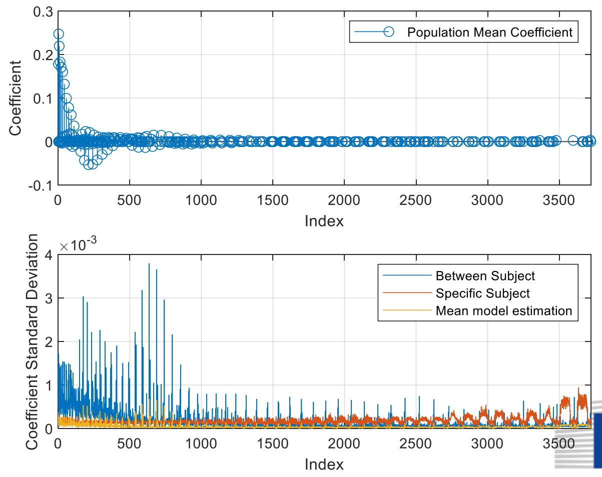
$$G_f^i\Big|_{\theta_j,\varphi_k} = \sum_{n=1}^{N} W_{\Delta f_n}^{PSD}\, G(\theta_j,\varphi_k)$$

$$SH(\theta,\varphi) = \sum_{l=1}^{n} \sum_{m=-l}^{l} Y_{lm}(\theta,\varphi)\beta_{lm}$$

$$\mathbf{G}_{m,\sigma}^{R}(\theta,\varphi) = \mathbf{SH}(\theta,\varphi)\widehat{\boldsymbol{\beta}_{\mu}}$$







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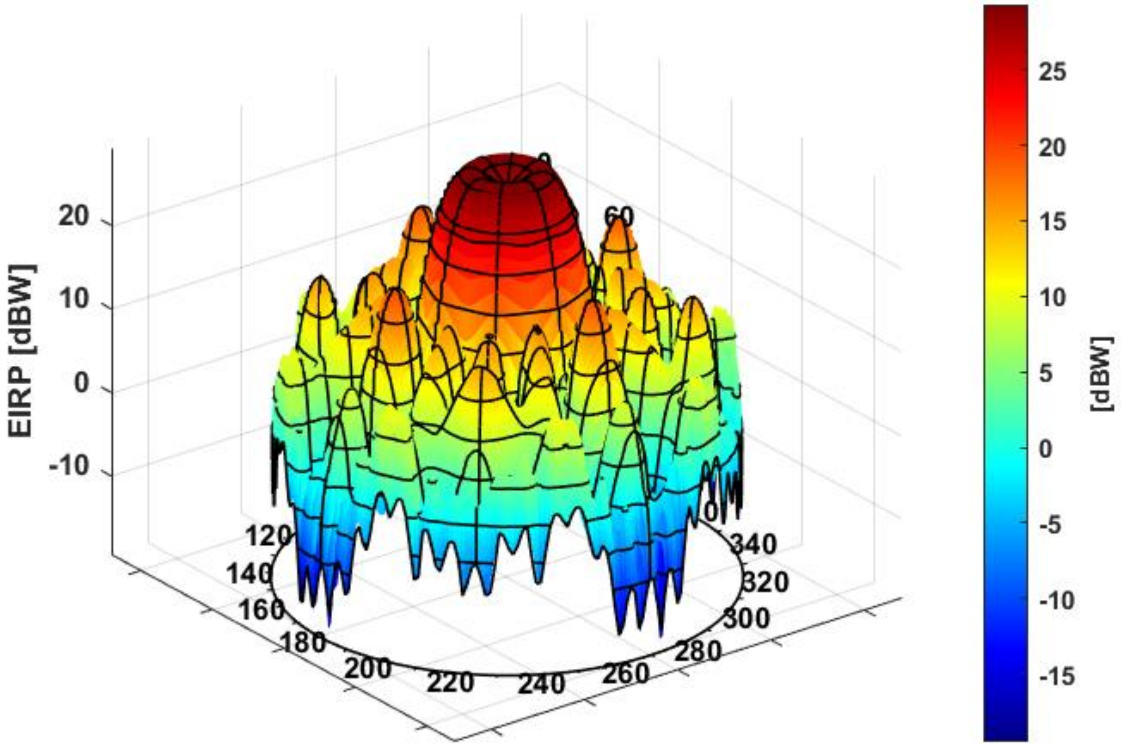
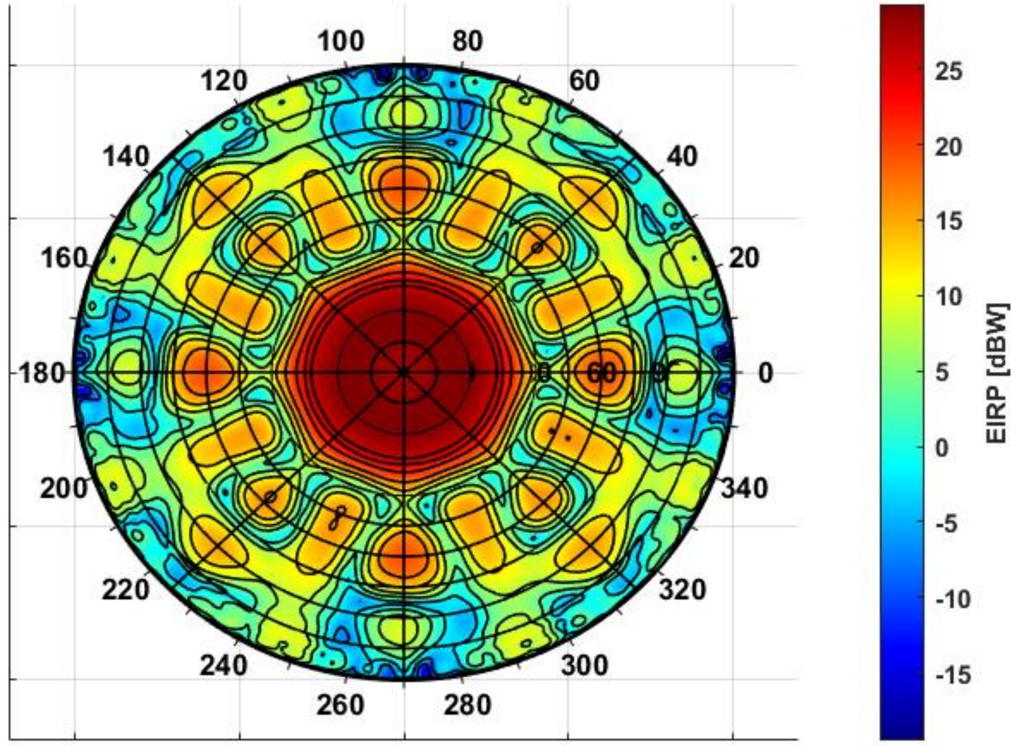
Results examples



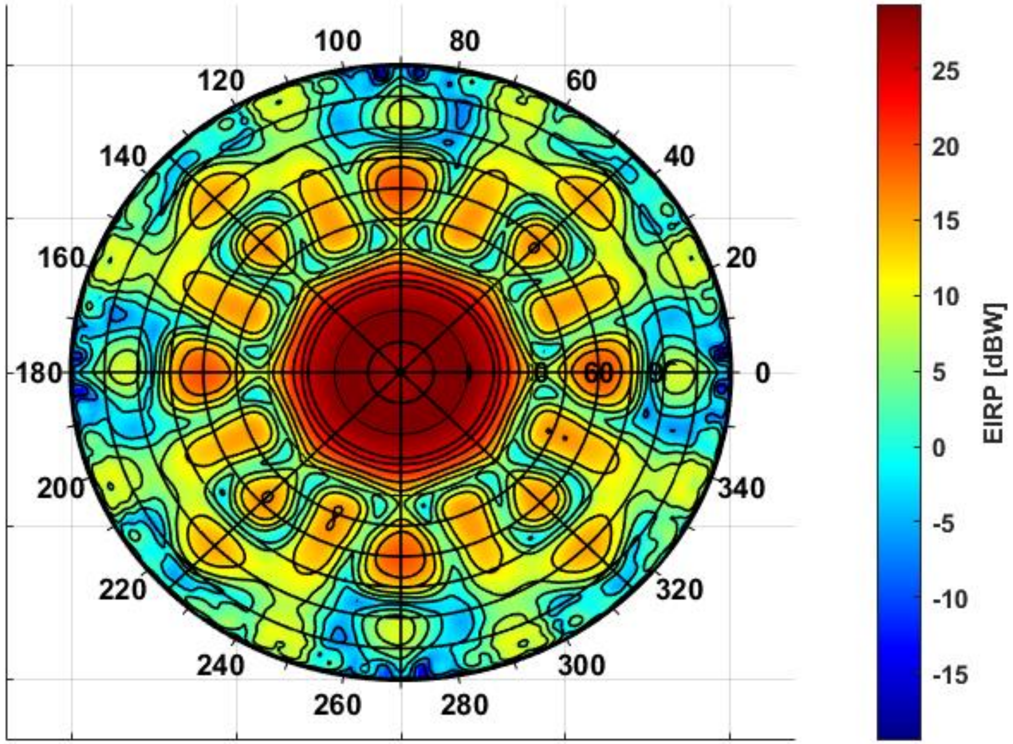
Galileo E1-BC 3D Constellation [dBW] $EIRP_{GRAP,E1-BC,dBW}$



Galileo E1-BC 3D Constellation [dBW] $EIRP_{GRAP,E1-BC,dBW}$ - polar view

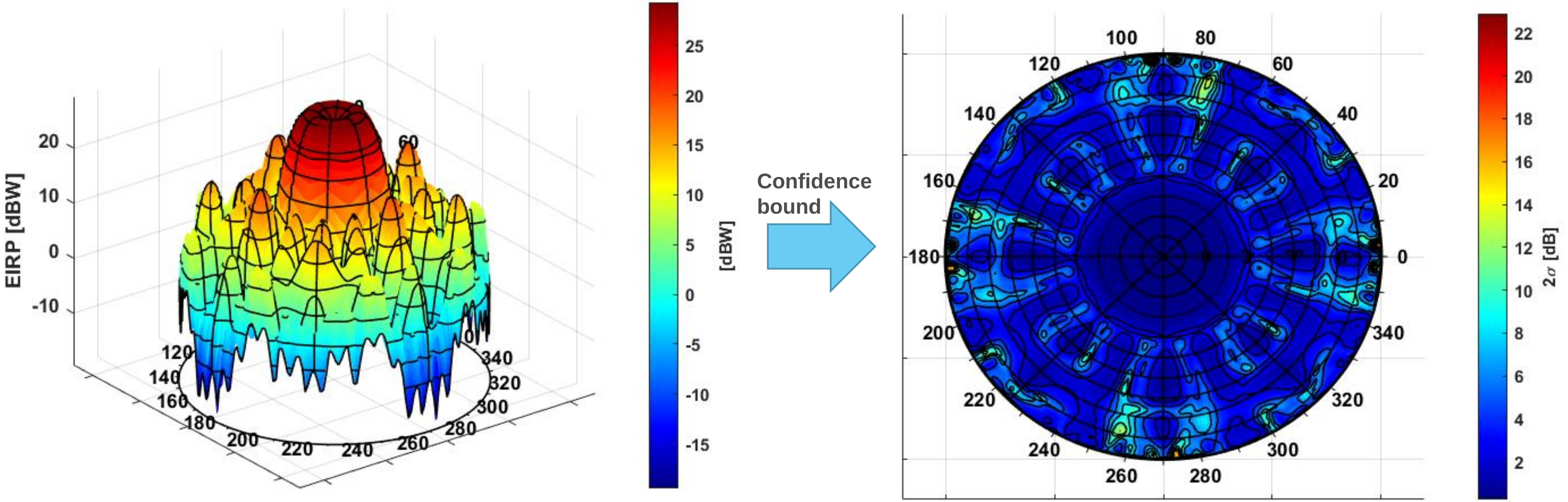
Results examples

- The Galileo Reference Antenna Pattern is provided in terms of **Equivalent Isotropic Radiated Power** (EIRP) with respect to the azimuth and co-elevation angles.
- The EIRP corresponds to the minimum user received power at ground level according the Galileo OS SIS ICD for the different signals (i.e. E5ab-IQ, E6-BC and E1-BC)



Galileo E1-BC 3D Constellation [dBW] $EIRP_{GRAP,E1-BC,dBW}$ **- polar view**

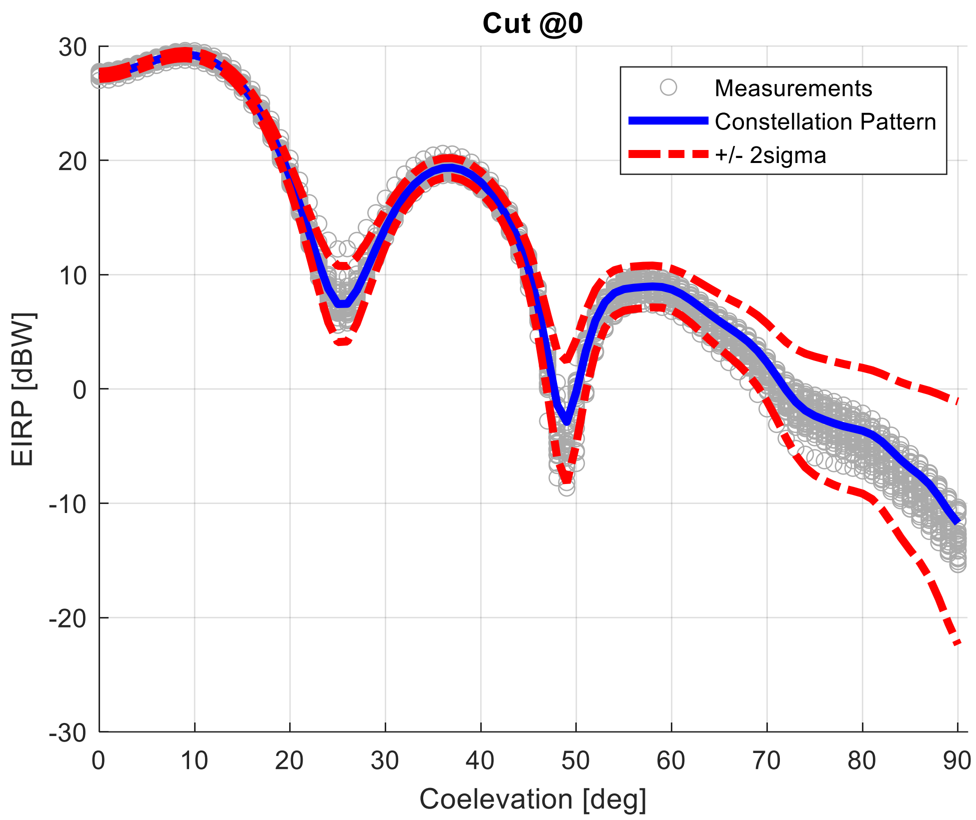
Results examples



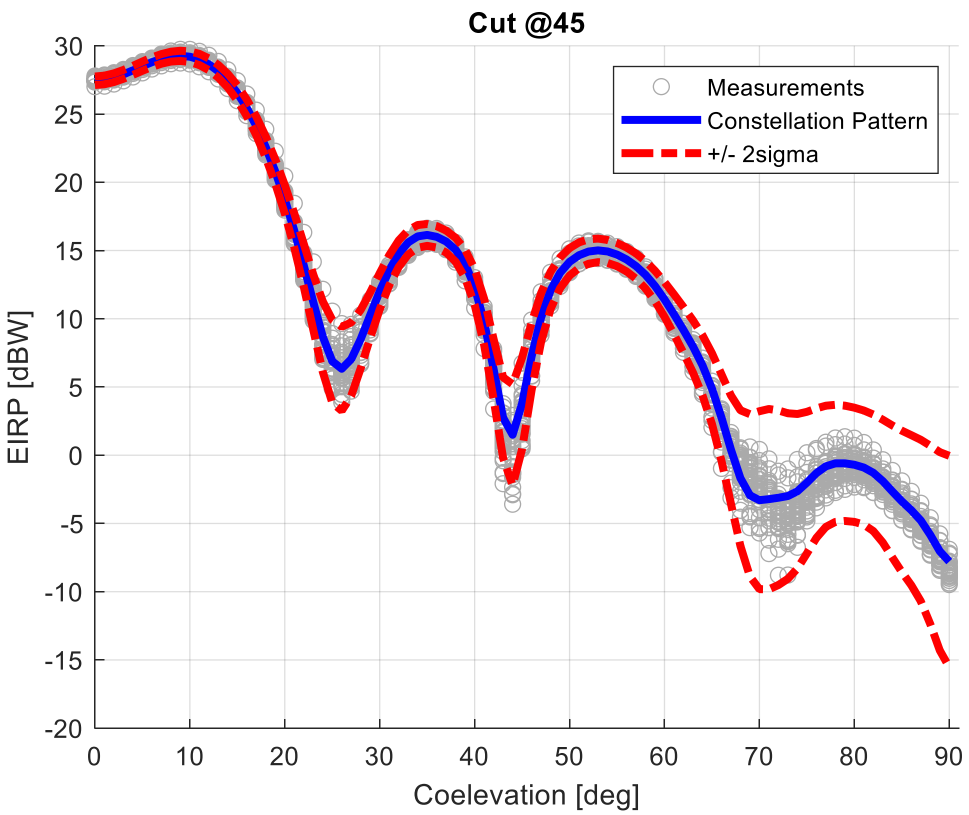
Galileo E1-BC 3D Constellation [dBW] $EIRP_{GRAP,E1-BC,dBW}$

Galileo E1-BC 3D Constellation EIRP expected 95% variation [dB] $2\sigma_{\mathrm{GRAP,E1}-BC,\mathrm{dB}}(\theta,\varphi)$- polar view

Results examples



Galileo E1-BC EIRP [dBW] (cut @0 deg azimuth) with expected 95% variation



Galileo E1-BC EIRP [dBW] (cut @0 deg azimuth) with expected 95% variation

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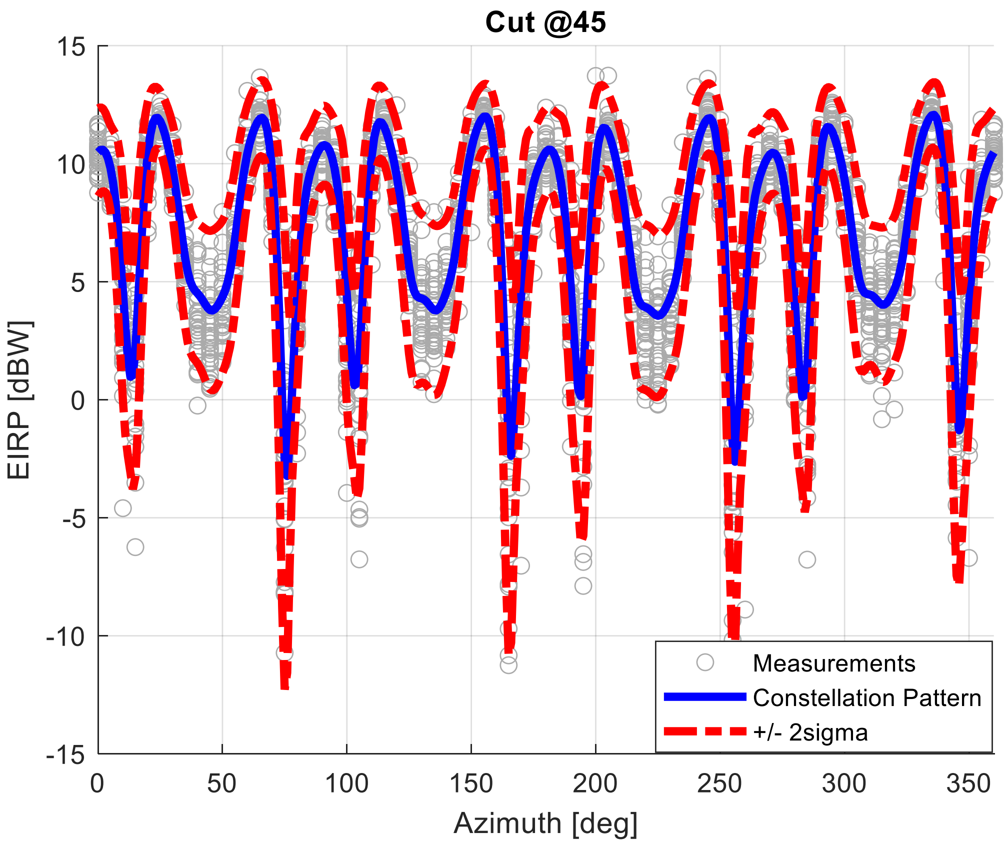
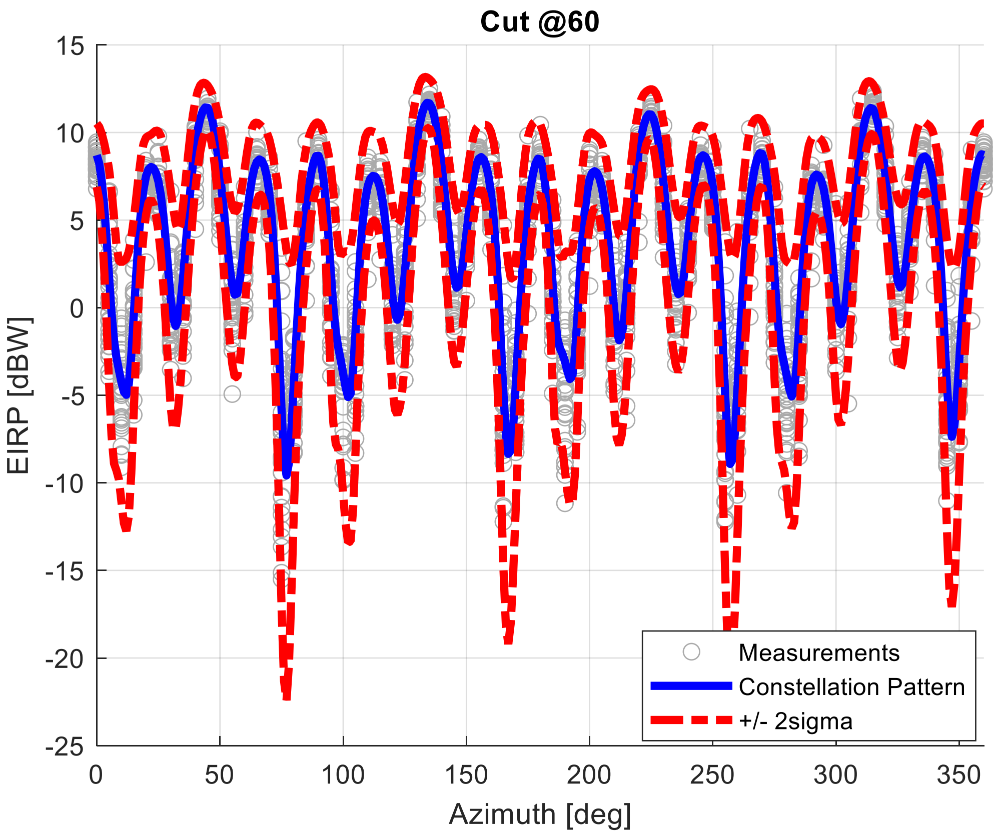
Results examples

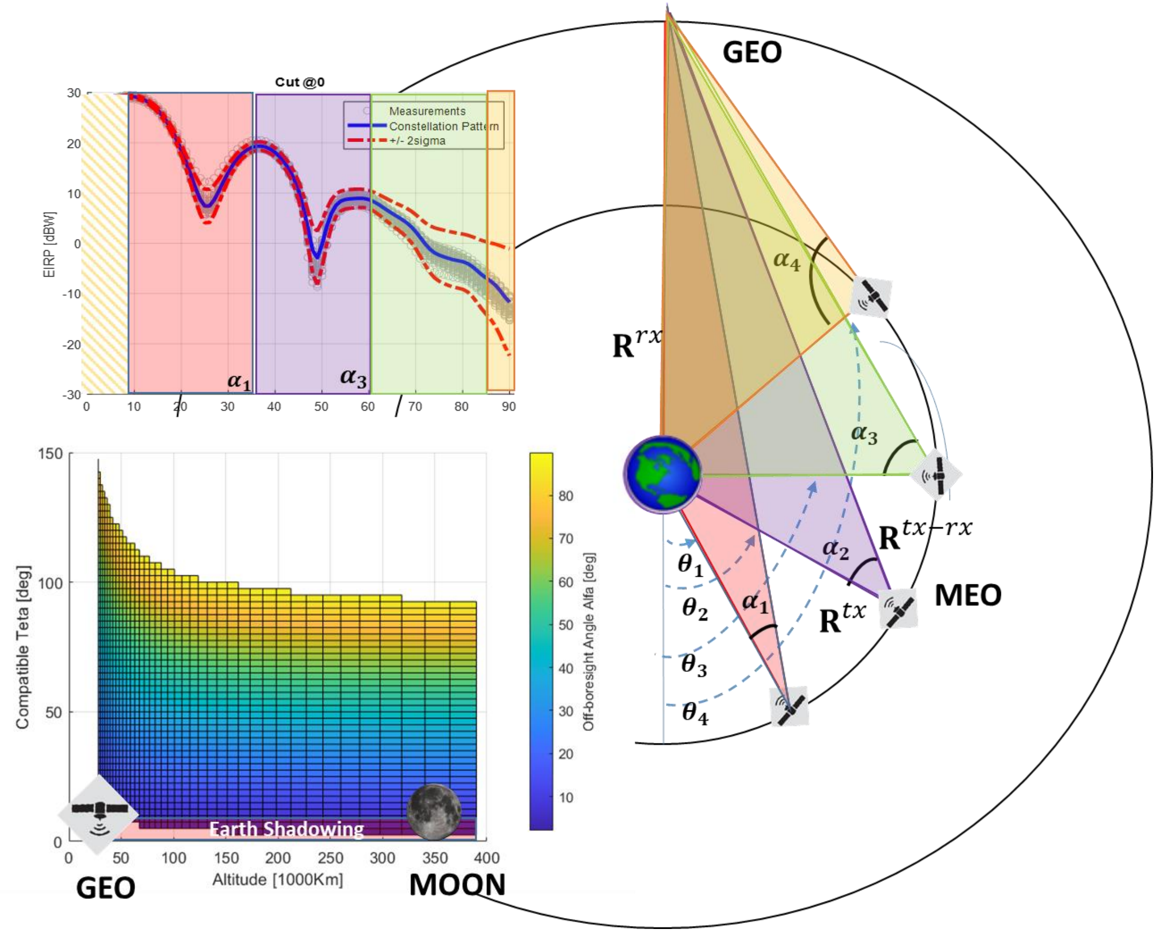


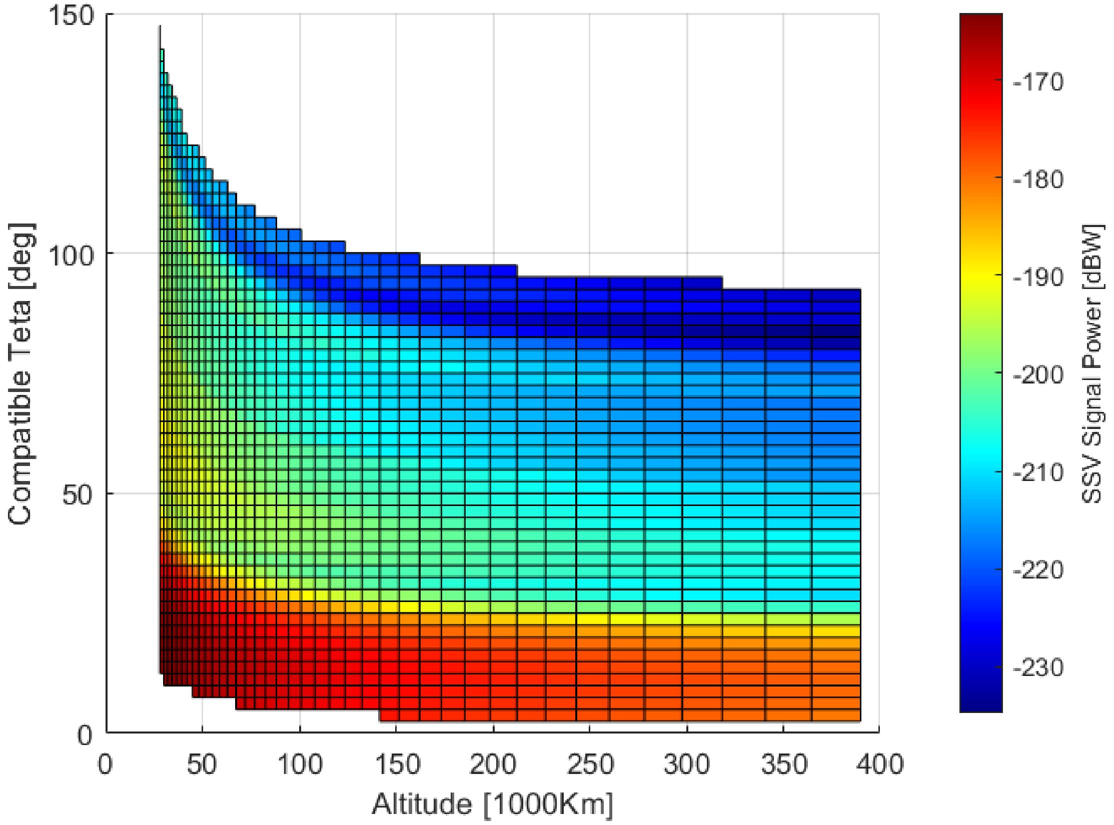
Galileo E1-BC EIRP [dBW] (cut @45 deg co-elevation) with expected 95% variation



Galileo E1-BC EIRP [dBW] (cut @60 deg co-elevation) with expected 95% variation

GALILEO PATTERN DRIVEN SSV LINK BUDGET ANALYSIS





Galileo E1-BC Received Power with respect to MEO satellite position (Teta) and Altitude with respect to

MODEL METADATA

- The model metadata will be organized according to the following format

Symbol	Description	Size	Ref. File
$EIRP_{GRAP,f,dBW}(\theta,\varphi)$	EIRP [dBW]	[91x361], 1deg	GRAP_File_****.GRAP_EIRP_dBW_****.xls
$EIRP_{CI,f,dBW}(\theta,\varphi)\big\|_{(+)}$	EIRP Upper Bound (95%) [dBW]	[91x361], 1deg	GRAP_File_****.GRAP_UB_dBW_****.xls
$EIRP_{CI,f,dBW}(\theta,\varphi)\big\|_{(-)}$	EIRP Lower Bound (95%) [dBW]	[91x361], 1deg	GRAP_File_****.GRAP_LB_dBW_****.xls

where ****. is replaced by {E1__, E5a_, E5b_, E6__} according to the target frequency band.

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CONCLUSIONS

- The Galileo programme is deriving the Galileo Reference Antenna Pattern, covering the full pattern
- This task is a response to ICG recommendation and it is meant to support GNSS users in space
- The approach will allow to easily update the model if additional measurements become available
- Any feedback from users and GNSS provides within the ICG is highly welcome

Keep in touch

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Thank you

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