Doris ground antennas Radio Frequency characterization

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Based on Daniel Belot's Work and Report

2012 September 25th

OUTLINE

- CONTEXT, MOTIVATION
- MEASUREMENT AND ANALYSIS REQUEST
- MEASUREMENT CAMPAIGN
- RESULTS
- UPCOMING ACTIVITIES

CONTEXT, MOTIVATION

- An issue was raised by several IDS users about a possible bias in the position of the phase center of the DORIS ground antennas

Recommendation from IDS Governing Board (Lisbonne 2010)

- The vertical offsets between Starec and Alcatel antennas must be looked at. There could be a correlation between the scale errors and the numbers of Alcatel antennas.

- Action to provide calibration results of Alcatel and Starec antennas

MEASUREMENT AND ANALYSIS REQUEST

Analysis requested to CNES Antenna Department

1 Characterize STAREC antenna considering phase center position defined by the manufacturer

- ✦ Gain pattern
- ✦ Phase law

2 Compare this characterization with manufacturer's specifications

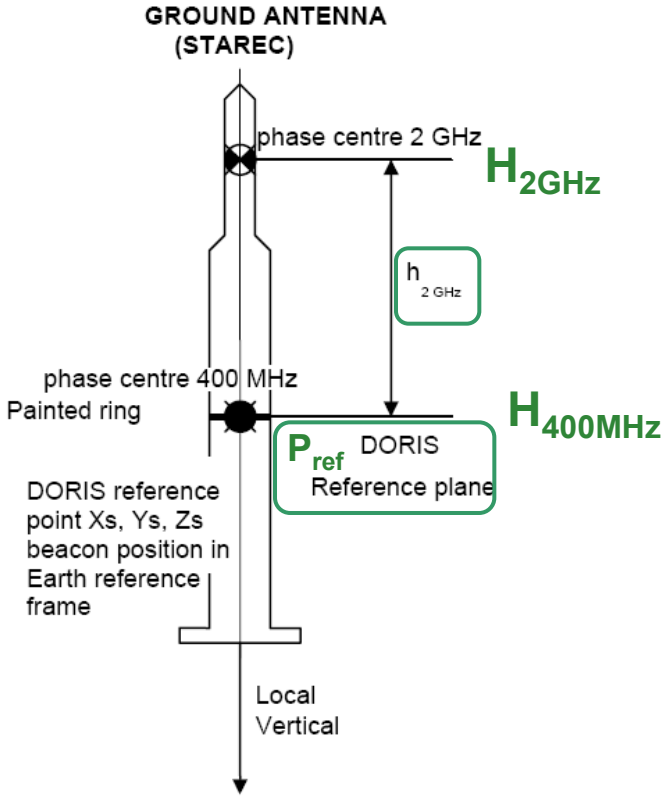
=> In case of inconsistency, determine the position of the phase center for which measured phase law corresponds to specifications

- Determine variability of the phase center position on a set of 7 STAREC antennas
  - » Type 52291 serial number : 50, 56, 128, 01
  - » Type 1828-25 serial number : 140, 143, 144

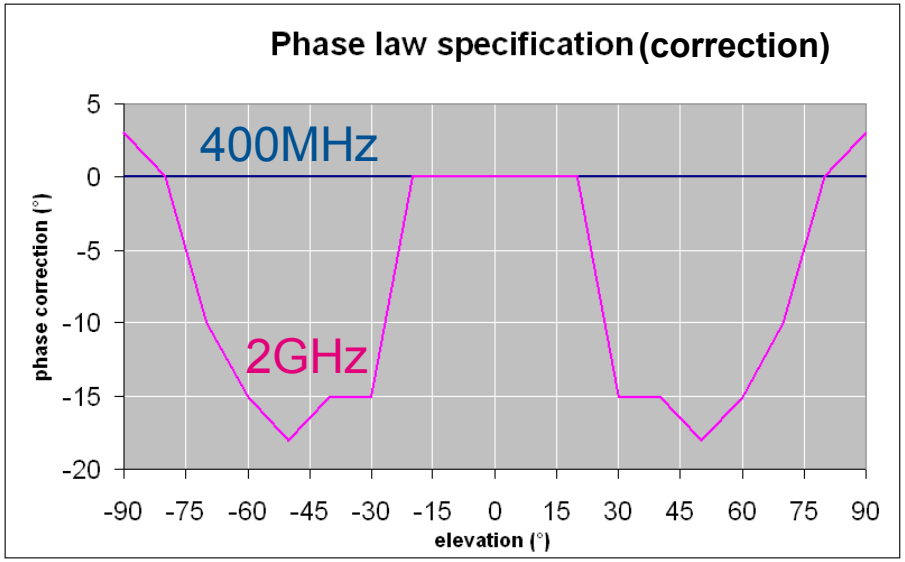
MEASUREMENT AND ANALYSIS REQUEST specification data

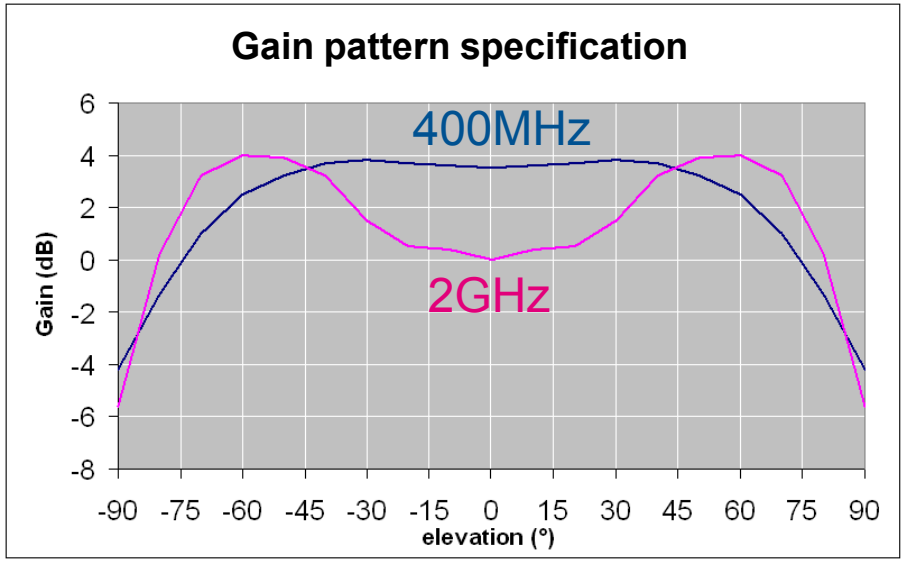
DORIS ground antenna : **STAREC**

- Specification document :
  - modeling of DORIS instrument (CO-SP-DO-OP-2460-CN)
  - Available on IDS site ftp://ftp.ids-doris.org/pub/ids/satellites/DORIS_instrument_modelling_1G_envisat.pdf
- Total size : 974 mm
- Reference plan : P_{ref} Doris Reference plan
- **H_{2GHz}** : 2036.25MHz Phase center : **487mm** / P_{ref}
- **H_{400MHz}** : 401.25MHz Phase center : **0mm** / P_{ref}



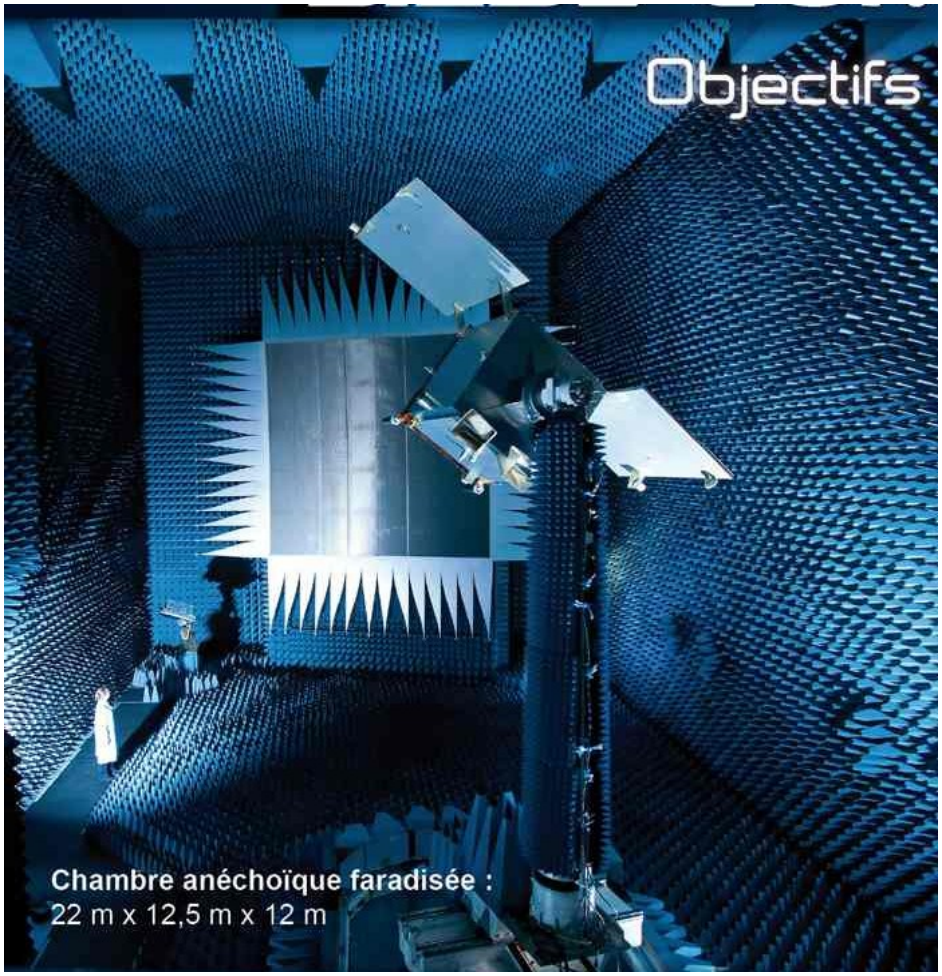
MEASUREMENT AND ANALYSIS REQUEST specification data





- dispersion authorized
  - 400 MHz : $\varepsilon = \pm 4°$
  - 2GHz : $\varepsilon = \pm 2°$

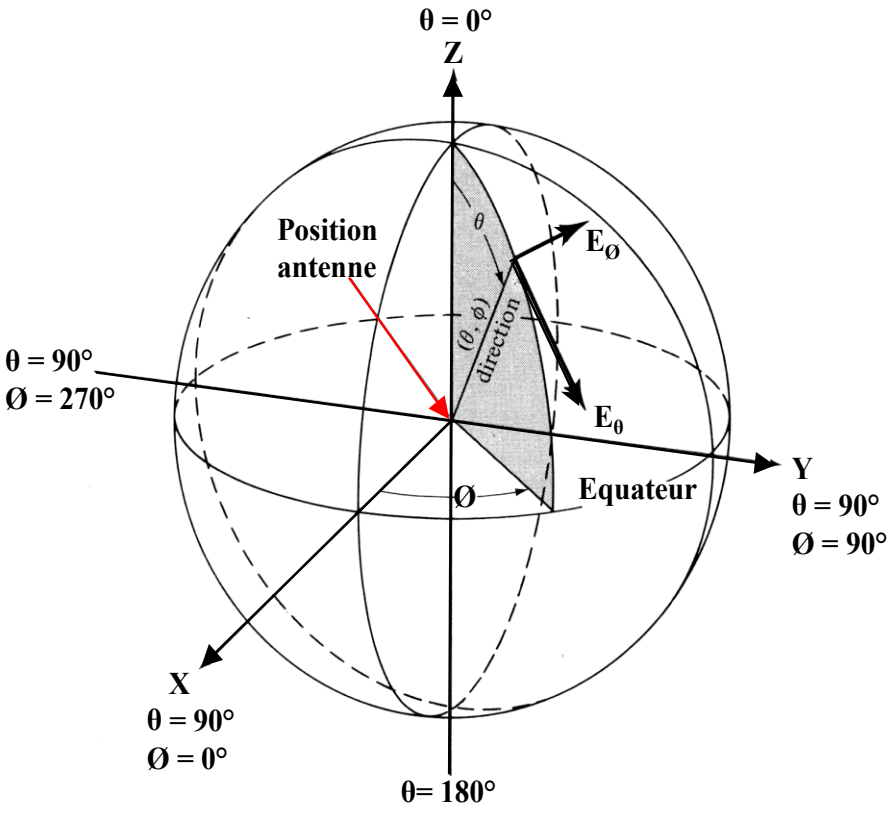
MEASUREMENT CAMPAIGN
Measurements performed by the CNES Antenna Department

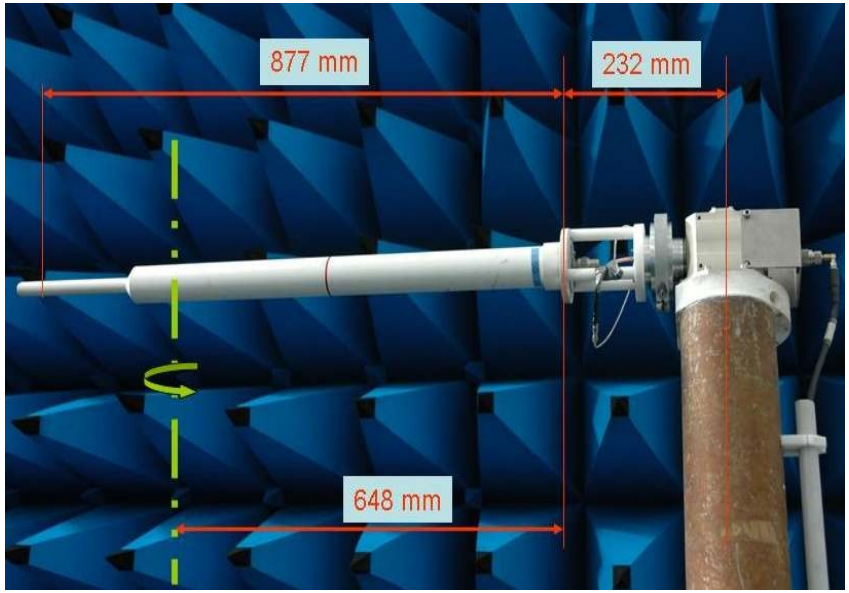


- **for more details, cf. backup slides**

MEASUREMENT CAMPAIGN
Measurement protocol

- Antenna placed on measurement device
- Antenna aligned with the Z axis of the measurement frame
- Antenna rotates to cover elevation angle (θ) from -180° to 180°
- 4 measurement series (4 plans) ϕ = 0°, 45°, 90°, 135°



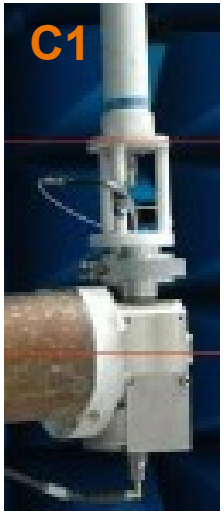


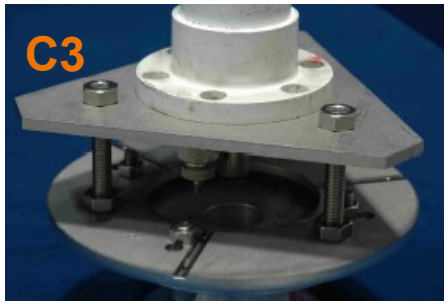
MEASUREMENT CAMPAIGN
Measurement configuration (1/2)

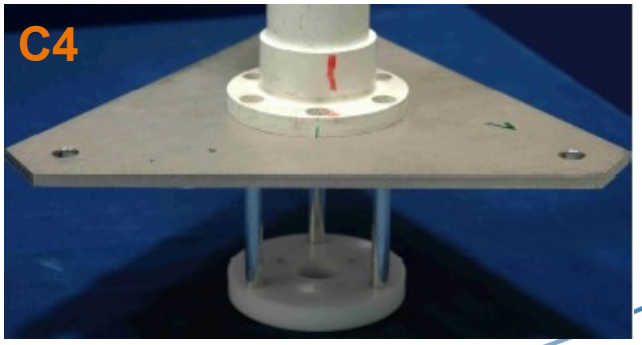
- Several configurations exist on the network
- In order to quantify the impact of the configuration, each one has to be measured
  - C1 : Doris antenna alone
  - C2 : Doris antenna on small triangular interface
  - C3 : Doris antenna on small triangular interface + IGN disc
  - C4 : Doris antenna on large triangular interface

⇒Tests measurements have been performed on one antenna (n°56)

⇒Measurements performed for the 4 configurations







MEASUREMENT CAMPAIGN
Measurement configuration (2/2)

- **Results :**

C1 : reference position of phase center (antenna alone)

C2 : Phase center position shift -2mm

C3 : Phase center position shift -2mm

C4 : Phase center position shift -3mm

⇒ **Impact of the interface under the accuracy specification for phase center position (± 5mm)**

⇒ **Impact of the interface in the measurement noise**

Measurements performed in C1 configuration (antenna alone)

Significant for all configurations

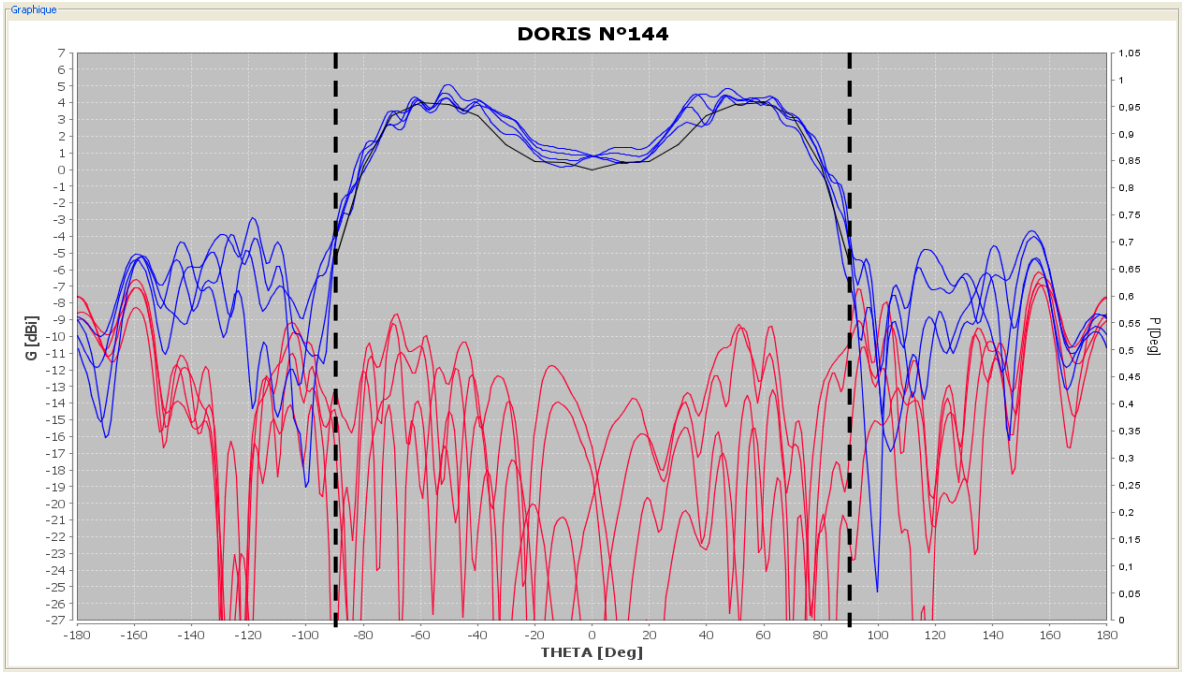
RESULTS
(7 STAREC Antennas)

From 2 measurement reports:

- DORIS Antennes sol : DCT/RF/AN - 2011.0024572
- DORIS antennes 56, complément de mesure

Gain pattern

- **Black curve : specified gain law**
- **Blue curves : gain measured on right hand polarized signal (useful signal)**
- **Red curves : gain measured on left hand polarized signal**



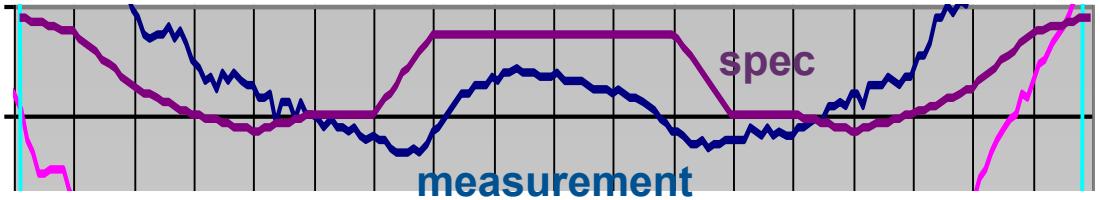
⇒Good consistency between measurement and specification for both 400MHz and 2GHz

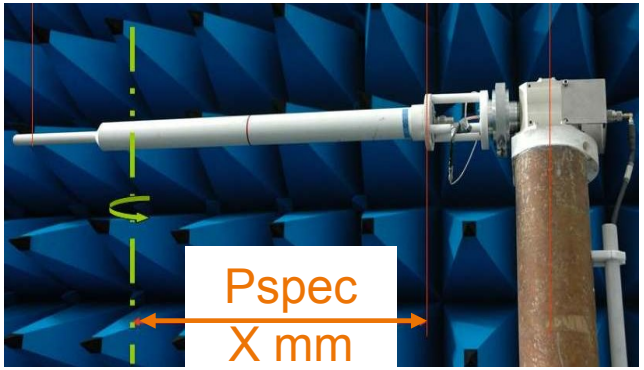
⇒Results equivalent for the 7 antennas

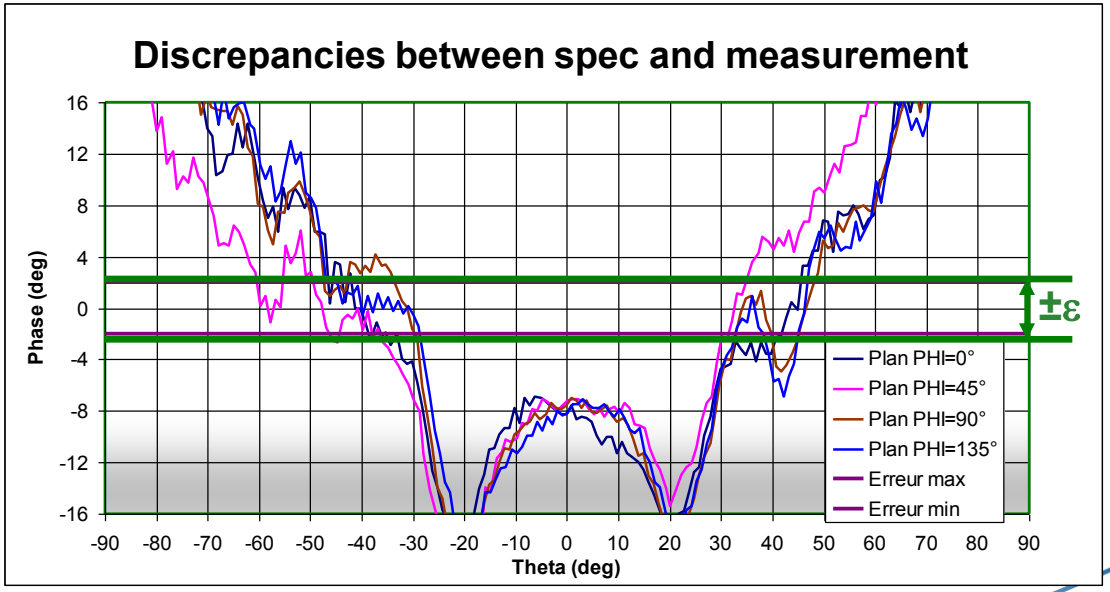
Phase law, phase center position measurement principle (1/2)

Considering the specified phase center position

- measurements are performed
- compared to specification



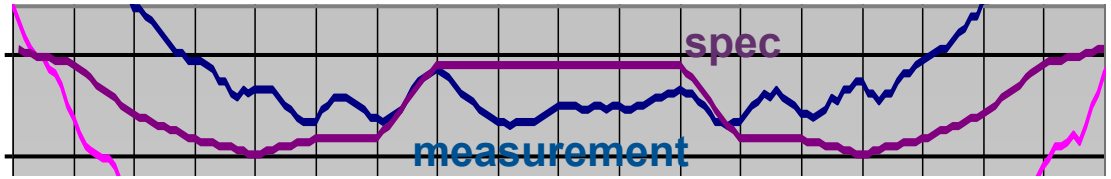


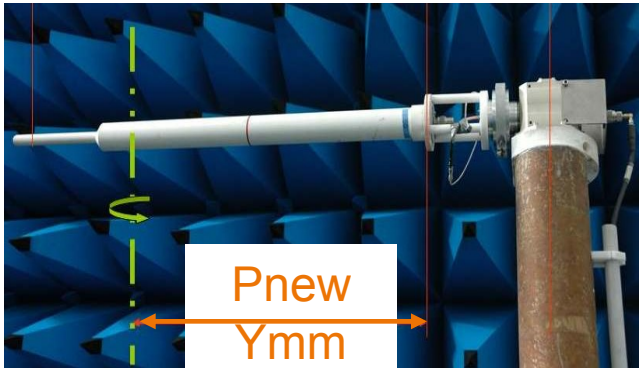


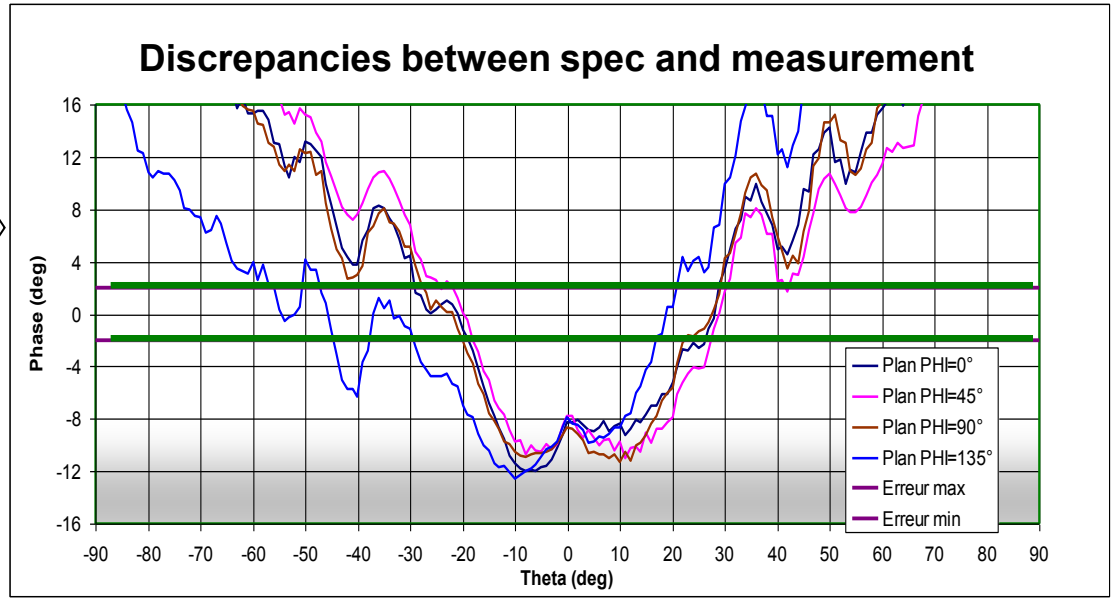
Phase law, phase center position measurement principle (2/2)

New position is taken into account

- Phase law is determined again
- compared to specification





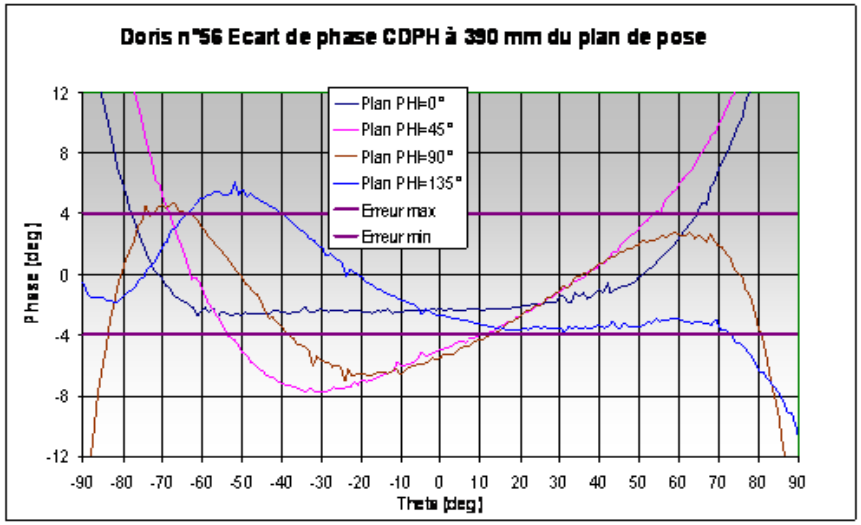


- After several iterations, a measured phase center position can be estimated

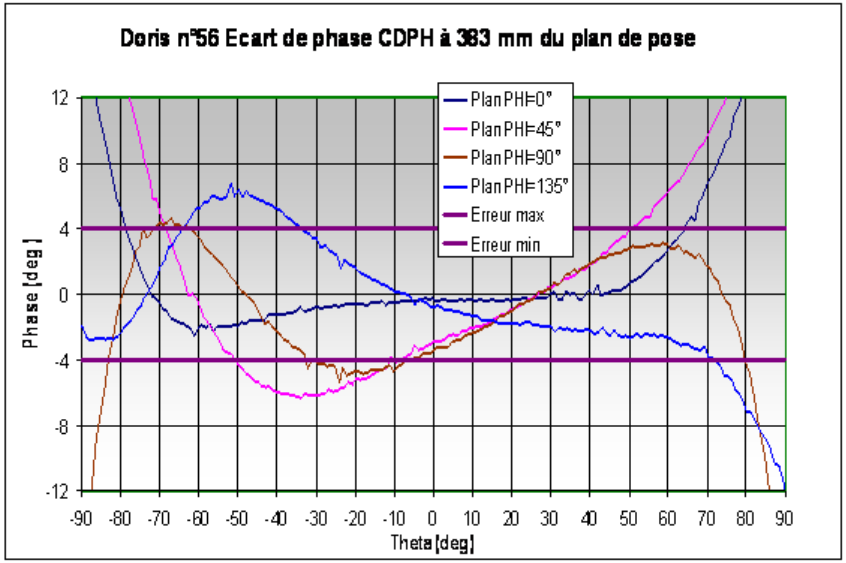
Results
400MHz Channel (1/2)

Phase center position :

- specified phase center position :
  0mm / P_{ref}



- Measured phase center position :
  -7mm / P_{ref}
  => **7mm** of discrepancies **(0.01 λ)**



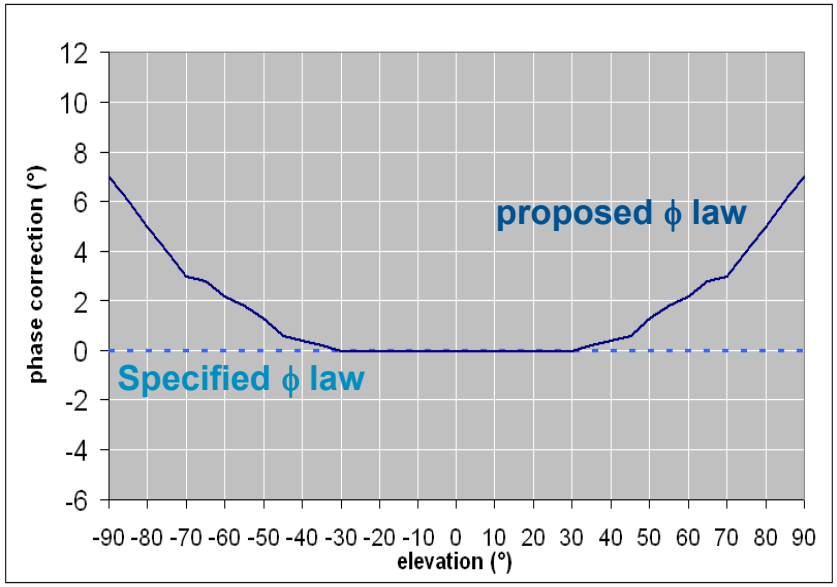
(consistent results obtained on 7 antennas)

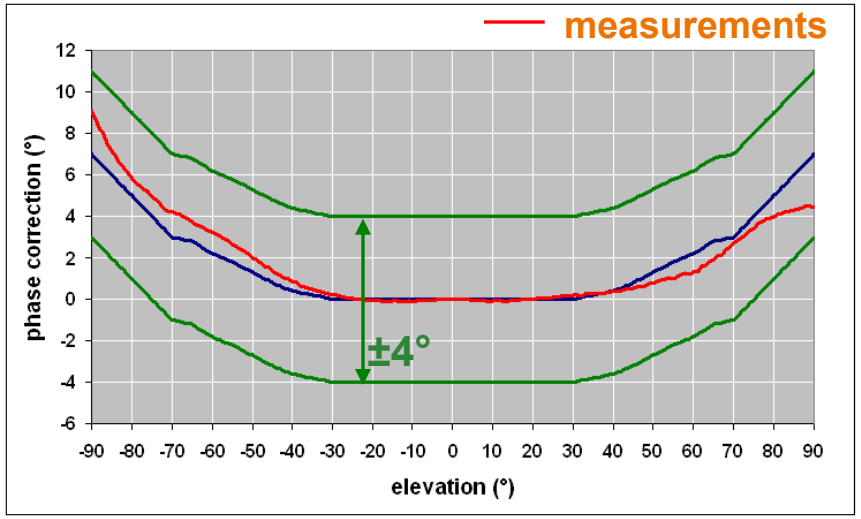
However :
discrepancies between results obtained with specified and measured phase center do not justify to change the specification

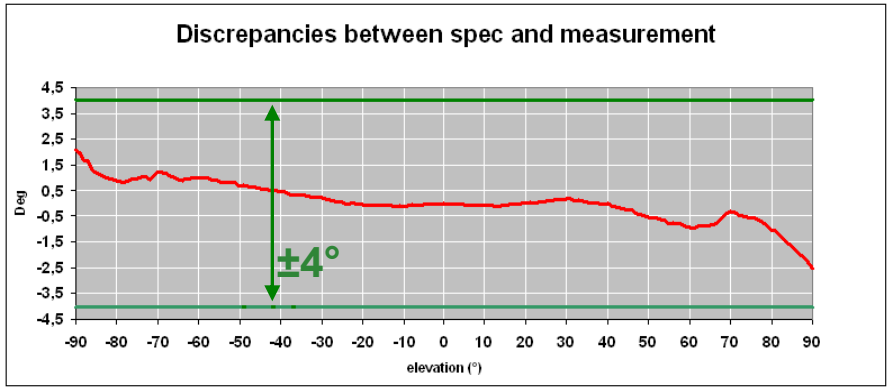
Results
400MHz Channel (2/2)

Phase law

- To stay in the ±4° dispersion, a new phase law is proposed :
  - Determined by adjustment on the 7 antennas measurements





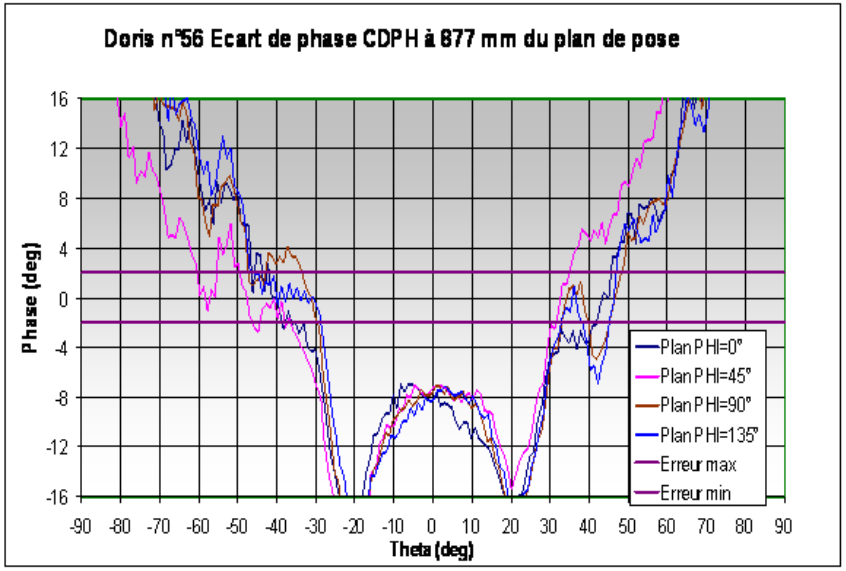


Results
2GHz channel (1/2)

Phase center position :

- specified phase center position :

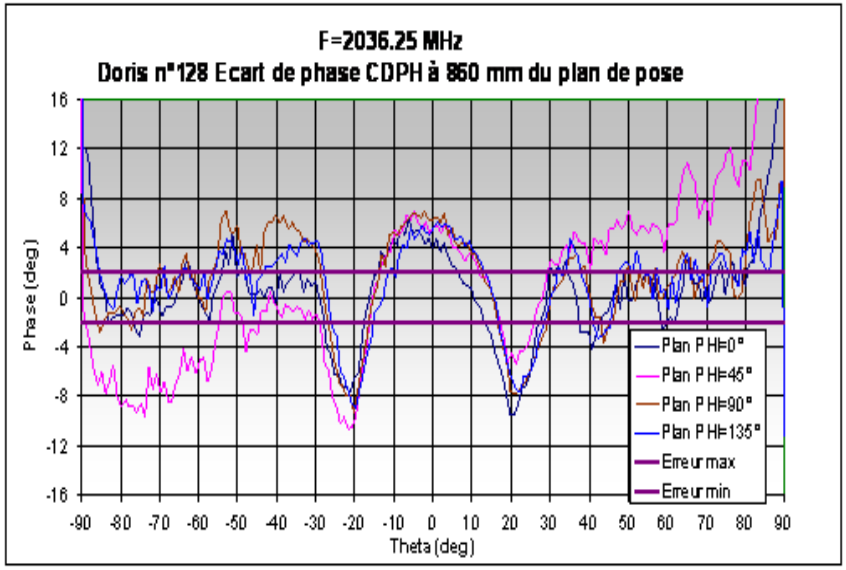
  487mm / P_{ref}



- Measured phase center position :

  470mm / P_{ref}

  => **17mm** of discrepancies (**0.12*λ**)

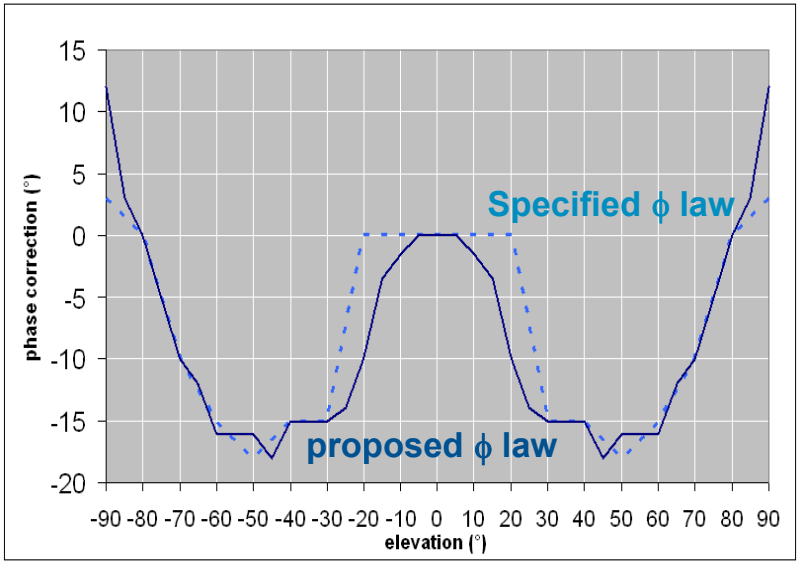


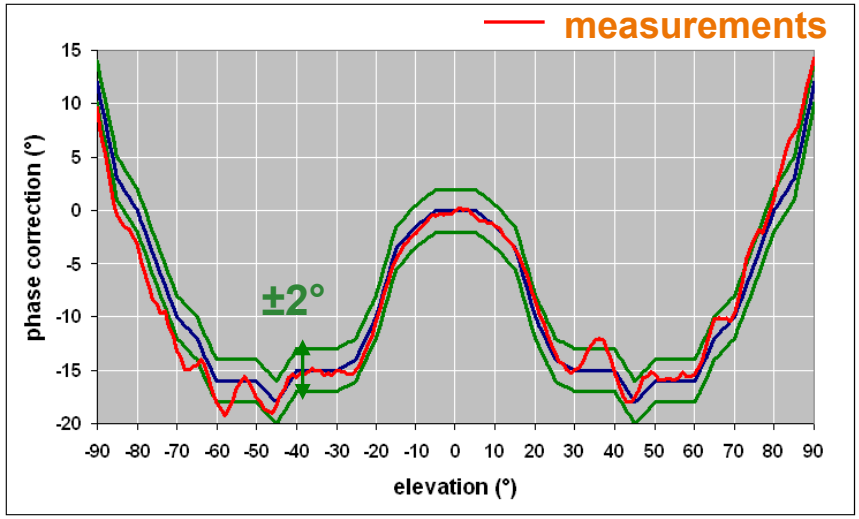
(consistent results obtained on 7 antennas)

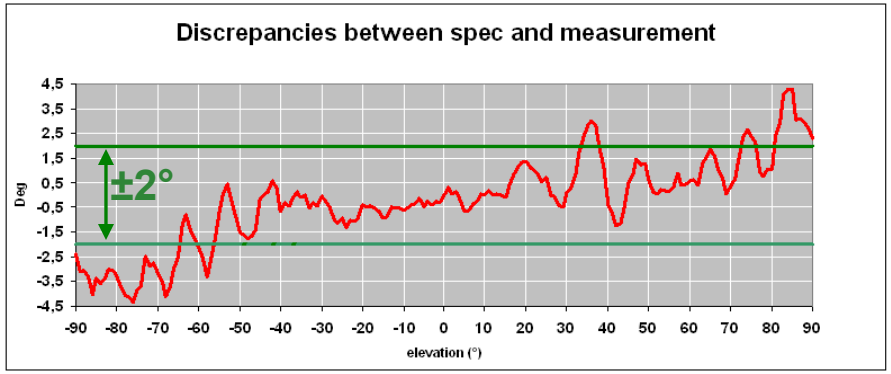
Results
2GHz channel (2/2)

Phase law

- To approach the ±2° dispersion, a new phase law is proposed :
  - Determined by adjustment on the 7 antennas measurements







DORIS STAREC antennas
Conclusion

Measurement campaign performed by antenna dep. shows :

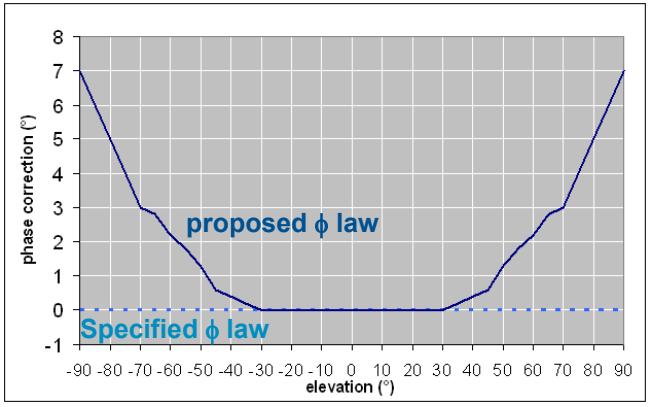
- **No variability of phase center position between antennas**
- **The specified 400Mhz phase center position does not need to be modified**

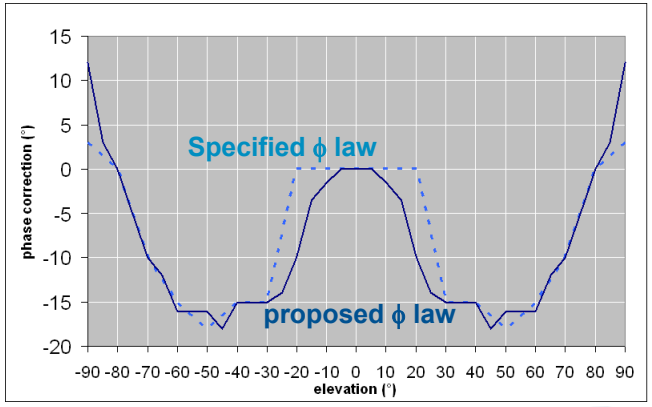
  => H_{400MHz} = 0 mm / Doris reference plane

- **The specified 2GHz phase center position should be modified**

  => H_{2GHz} = 470 mm / Doris reference plane

- **For both channels , the measured phase law should be applied**





NEXT

Before applying specification modification :

Analysis of the impact of those new values on IDS solutions needed:

- This work is on going.

Similar analysis on ALCATEL antennas if possible

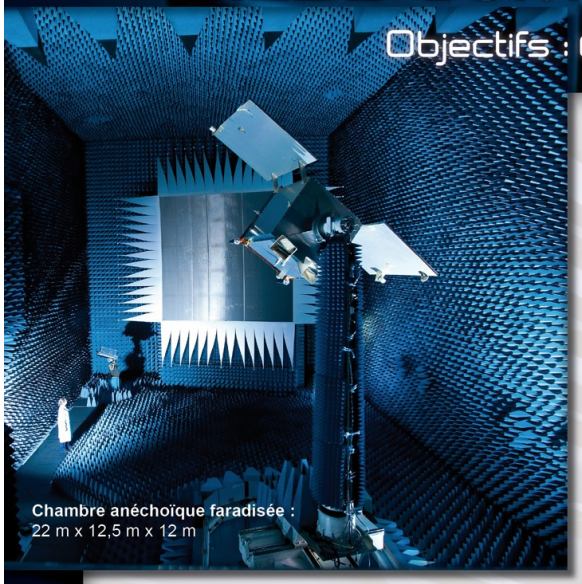
- Need to have a significant set of antennas
- On going investigation to get functional antennas

THANK YOU

Backup slides

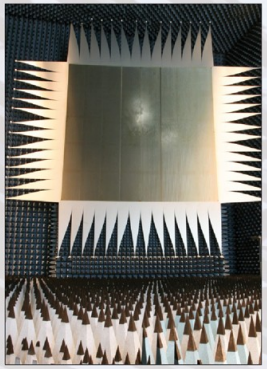
BASE COMPACTE DE MESURES D'ANTENNES

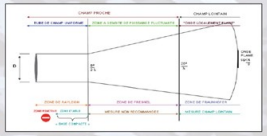
Objectifs : Connaître et maîtriser le rayonnement des antennes seules et sur structures



Chambre anéchoïque faradisée :
22 m x 12,5 m x 12 m

Simuler la distance satellite sol

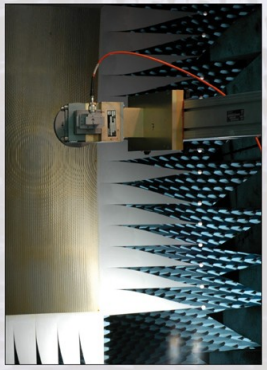




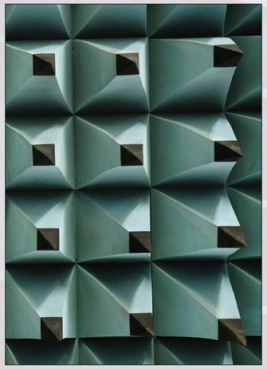
◄ **Réflecteur parabolique :**
5,3 m x 5,6 m, 48 tonnes.
- Focale : 13 m.
- Etat de surface : 25 µm RMS,
- Zone tranquille maximale de 4 m x 4 m x 4 m.

15 sources primaires ►
de 0,4 à 200 GHz.

Simuler la liaison bord sol



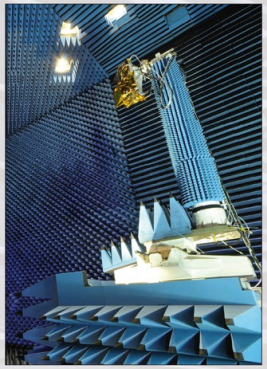
Isoler l'antenne dans l'espace



◄ **Absorbants :** -70 dB de réflectivité typique à 8 GHz.

Positionneur : 7 degrés de liberté en rotation et translation. Capacité : 350 Kg maximum. ►

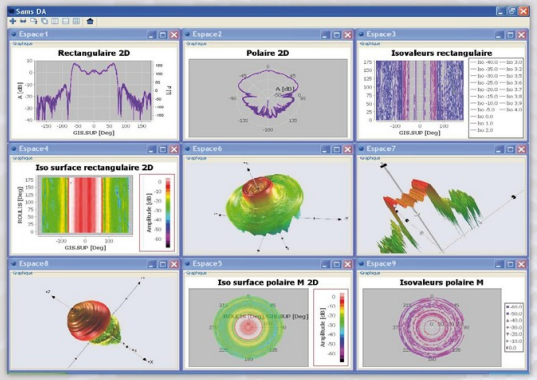
Positionner l'antenne dans l'espace



◄ Diagramme de rayonnement, directivité, gain, localisation centre de phase, temps de propagation de groupe. Performances système, surface équivalente radar.

Instrumentation : analyseurs de réseau Agilent et ABmillimètre, logiciels CNES/ SILICOM d'acquisition et post-traitement. ►

Réaliser les mesures avec précision



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