Doris ground antennas Radio Frequency characterization Status

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OUTLINE

- Reminder : Starec antenna characterization provided
- Analysis of dispersion w.r.t. azimuth angle
- CATR measurement error estimation
- DORIS ground antenna error budget

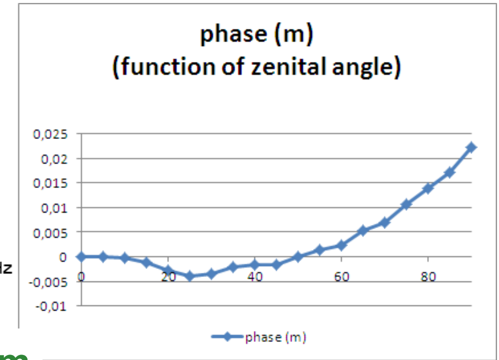
Reminder

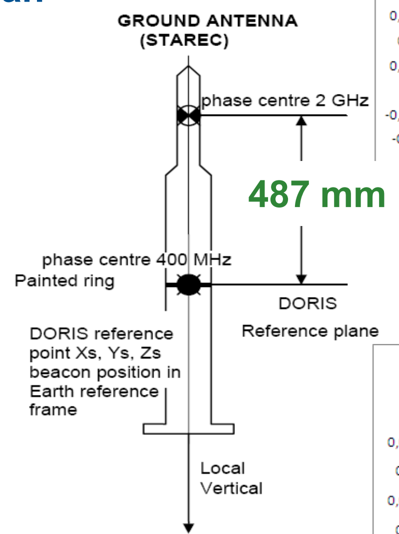
● Characterization provided for DORIS STAREC ground antennas

✦2GHz :

» **Phase center : 487 mm above the reference plan**

» **2Ghz Phase law :**

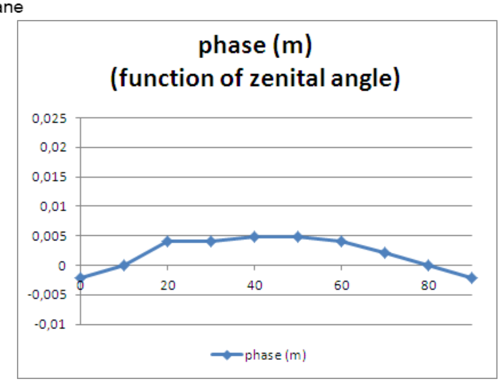




✦400 MHz : no change

» Phase center: 0 mm above the reference plan

» 400Mhz Phase law



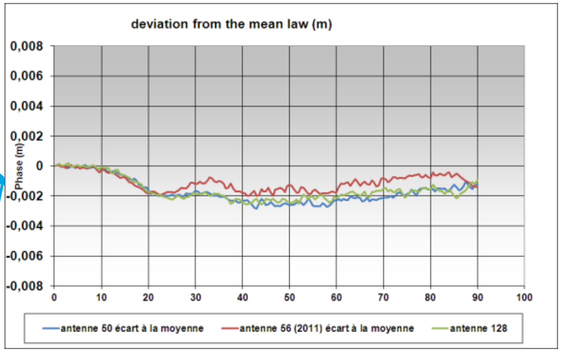
Characterizations provided via antex files (proper use described in specific slides)

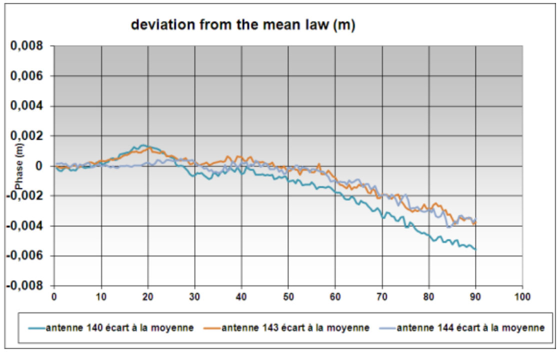
Antenna dispersion

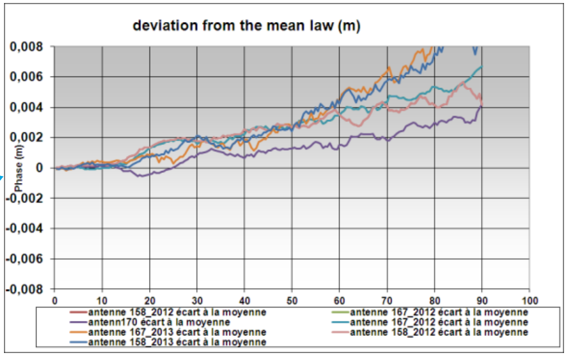
SALP — Service Altimetrie & Localisation Precise

- **Antennas characterized at CNES compact antenna test range (CATR)**
- **In parallel, a set of antennas dismantled**
  - **Distance between 2GHz radiating element bottom and mounting flange (TCMA)**

Batch	Antenna	TCMA (mm)
Starec	26	715
	50	715
	56	716
Juin 2000	61	710,5
Dec 2000 (64 80 82 85-> 134)	88	712
	90	712
	103	712
	118	713
	127	715
	128	
2006 (135-> 156)	140	
	143	
	144	
	149	714,5
	156	720
2012 (157 -> 170)	158	
	167	
	170	713







- Distance corresponding to the mean law provided via antex files : 716mm
- Dispersion wrt this distance : -6mm /+4mm for old antennas (SN < 171)
- **Future antennas : distance guaranted at 716 ±1mm (from SN 171)**

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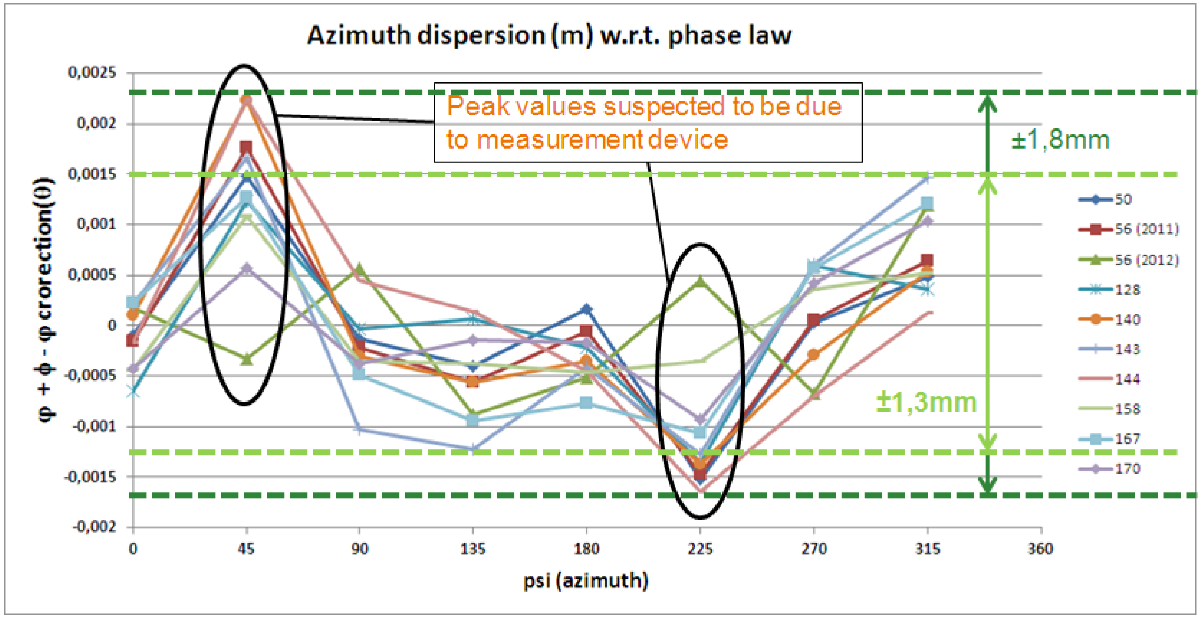
Analysis of dispersion w.r.t. azimuth angle first analysis (2/2)

- Usual analysis performed by the CATR Compact Antenna T Room
  - 9 antennas analyzed
    - **4 plans (4 azimuth angle): ϕ = 0°, 45°, 90°, 135° ; with θ going from -180 to 180°**
    - **8 samples of azimuth measurements**

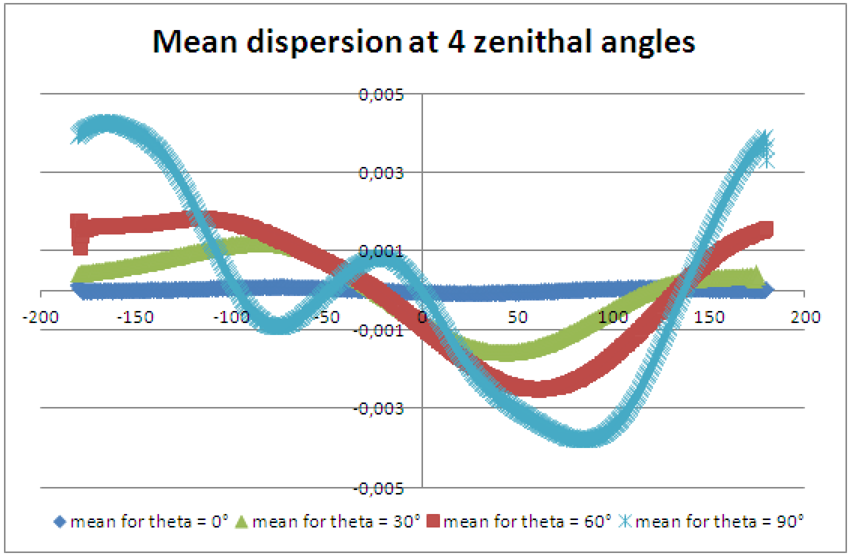
- We get an estimation of the dispersion (θ averaged) :



- We observe an azimuthal dispersion of
  - ±1,8mm including peak values

Analysis of dispersion w.r.t. azimuth angle Second analysis (1/2)

- Specific analysis performed at CATR
  - 3 antennas analyzed :
    - » **4 plans (4 zenithal angle): θ = 0°, 30°, 60°, 90°; with ϕ going from -180 to 180°**
  - To eliminate inter-antennas variability
    - » **we determine the mean dispersion over all antennas**
  - mean azimuthal dispersion for 4 zenithal angles
  - the mean over θ angle is ± 1,8mm
    - ⇒ **Consistent with first analysis**



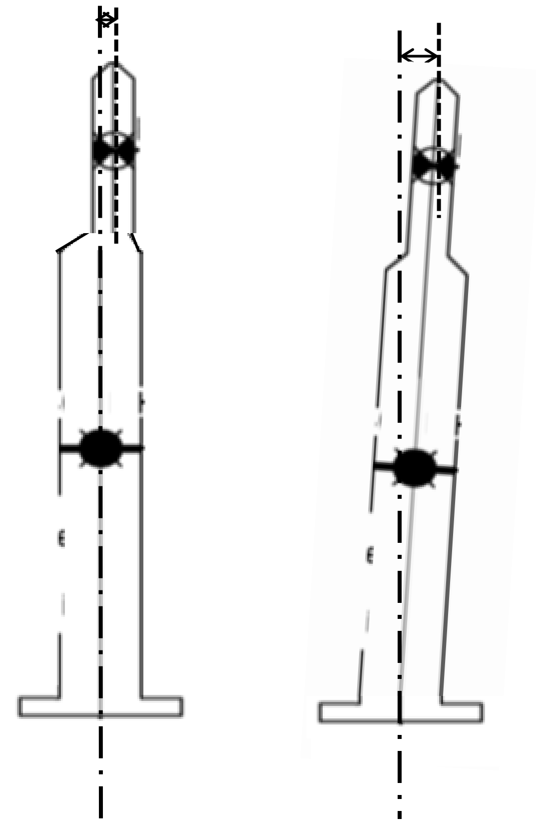
θ	Max dispersion
0°	0 mm
30°	±1,4mm
60°	±2,15mm
85° (interpolation)	±3,7mm
90°	±4 mm

- Impact of dispersion :
  - » **Law θ values :**
    impact on the up component
    small dispersion => small impact on up
  - » **High θ values :**
    impact on the N/E component
    greater dispersion (±3,7mm at 85°)
    => greater impact
    for standard passes we can estimate a max impact of ±3mm

- This dispersion includes:
  - » **True Azimuthal RF dispersion**
  - » **Perpendicularity / Coaxiality defaults of Antenna axis w.r.t. Mounting flange**
  - » **Centering default of radiating elements**
  - » **CATR eventual default, rotation axis perpendicularity**

Antenna axis eventual defaults

misalignment **perpendicularity**

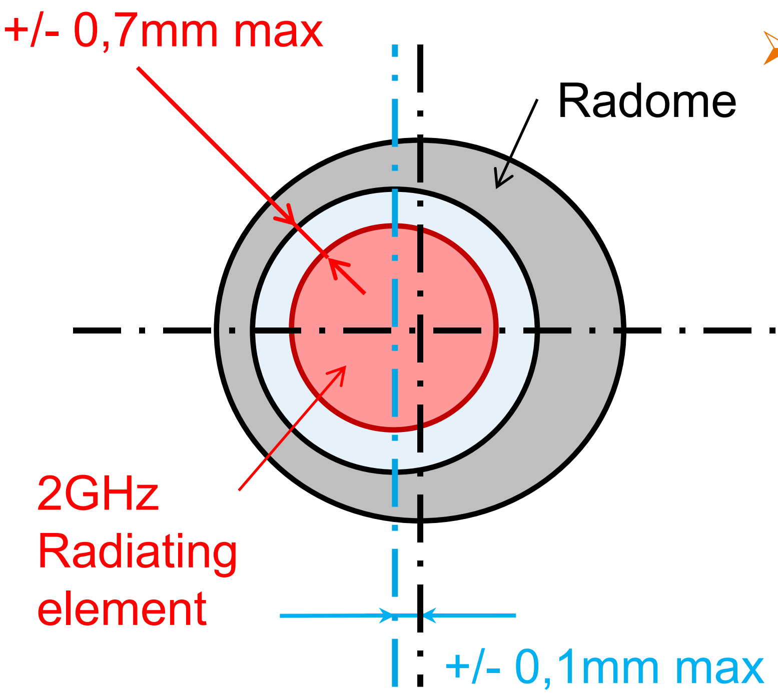


- Misalignment / perpendicularity defaults
  - Now controlled by manufacturer on a machine tool w.r.t. mounting flange (plane&axis)
  - The error due to non perpendicularity or misalignment does not exceed : ±0,5mm at antenna extremity

=> This implies an error in the horizontal plane

≈ ±0,5mm of 2GHz phase center position N/E

Centering default of 2GHz radiating elements



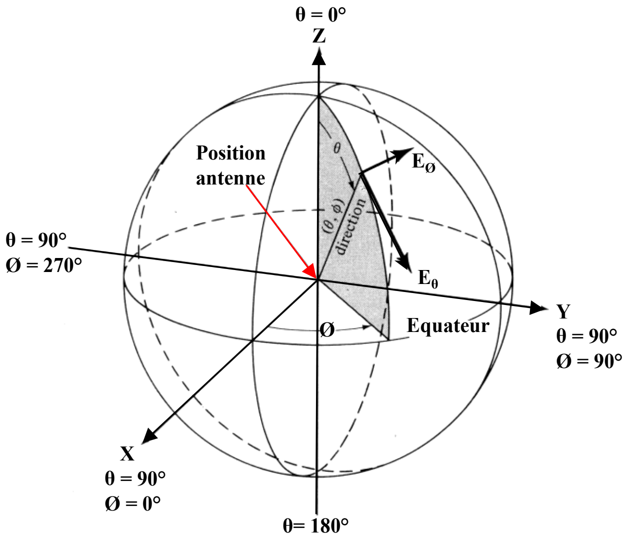
- Perpendicularity of the radome external skin axis is controlled by the manufacturer with respect to mounting flange
- Remaining internal / external discrepancies
  - Irregularity of radome thickness
  - clearance between radiating elements and radome

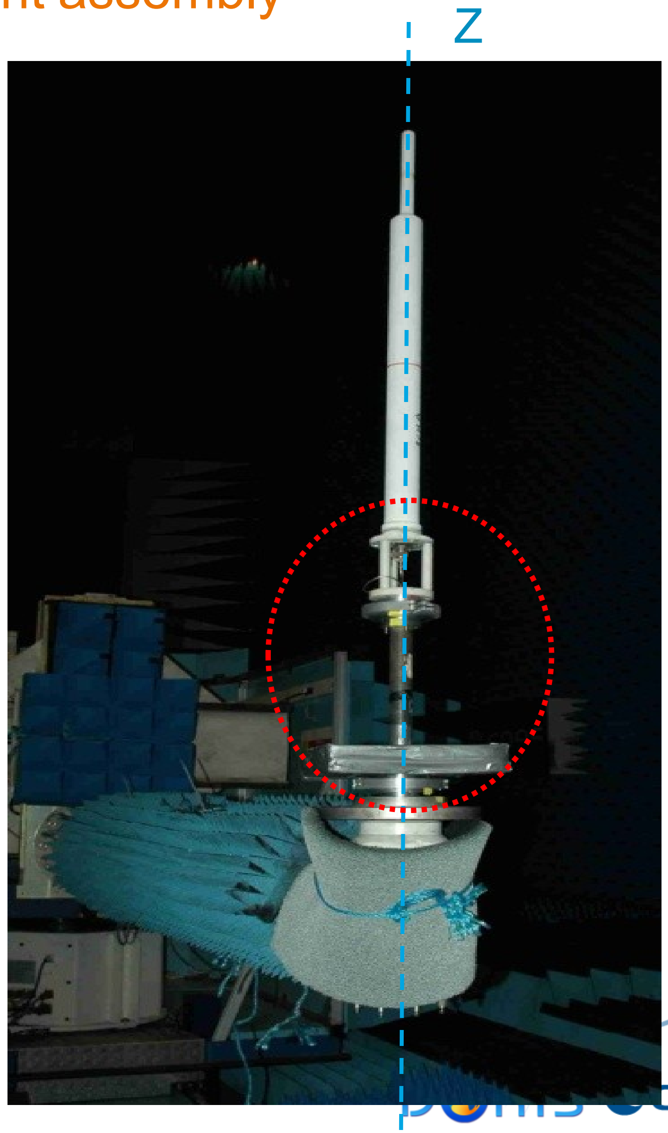
Discrepancy between internal axis and radome external surface	± 0,1mm
Gap between radiating element and internal radome surface	± 0,7mm
total	**± 0,8mm N/E**

Antenna perpendicularity default in CATR

Perpendicularity default due to measurement assembly

- Antenna aligned on Z axis of measurement device
- Antenna is set on measurement device thank to mechanic interface
  - Perpendicularity is not totally perfect
  - Default assumed : **± 1 mm** at 2GHz height (887mm)





Analysis of dispersion w.r.t. azimuth angle Conclusion

- The two analysis performed lead to the same result :
  - A maximum azimuthal dispersion of ±1,8mm (theta averaged)

- The worst impact of azimuthal dispersion would be ±3mm in horizontal plane (N/E), assuming the dispersion is totally due to antenna
  - But ±1mm is probably due to CATR measurement assembly

- This allows to establish the following azimuth error budget

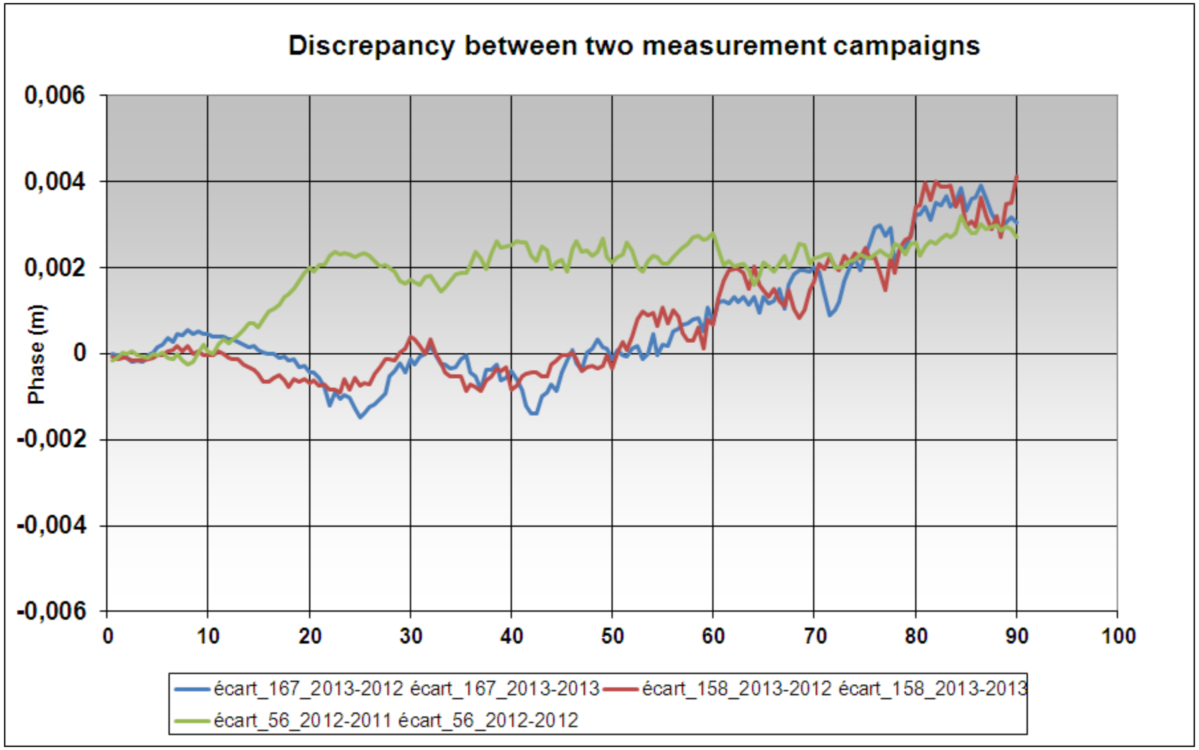
Antenna Azimuth error budget	
Error source	**N/E impact**
Total observed	**±3 mm**
CATR assembly	**±1 mm**
=> Total antenna	**±2 mm**
Perpendicularity	**±0,5 mm**
Centering	**±0,8 mm**
=> Azimuth phase pattern variation	**±0,7 mm**

- We assume the DORIS STAREC antenna is non azimuth dependent
  - Not really a surprise, STAREC antenna is helicoidal, it has a revolution symmetry by conception

CATR measurement error

The CATR has it own measurement error

- To get an estimation of this error
  - Some antennas characterized twice at CATR at 3 different epochs
  - Measurement discrepancy observed : 4mm max



⇒ We assume a **CATR measurement noise error** of **±2mm (up)**

DORIS Ground antenna error budget

Error source	up	plan (N/E)
Antennas variability (2GHz phase center position) before consolidation with manufacturer (SN < 171)	+4/-6 mm	
Antennas variability (2GHz phase center position) after consolidation with the manufacturer (From SN 171)	±1 mm	
Antenna characterization error (BCMA)	±2 mm	
Azimuthal dispersion (including RF, perpendicularity, centering)	0mm	± 2mm
Total antenna alone		
SN < 171	+6/-8 mm max 5,4 mm rms	± 2 mm max 0,7 mm rms
From SN 171	**± 3 mm max** 1 mm rms	**± 2 mm max** 0,7 mm rms
Antenna environment impact	TBD	TBD

Conclusion

- Antenna alone is now well characterized

- Future work :
  - Environment impact
  - Satellite antenna Characterization

THANK YOU

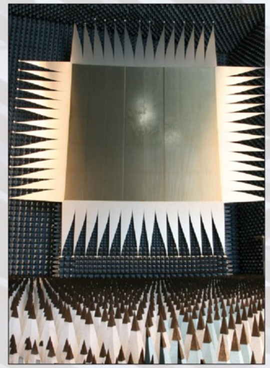
Backup slides

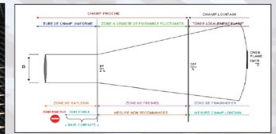
BASE COMPACTE DE MESURES D'ANTENNES

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

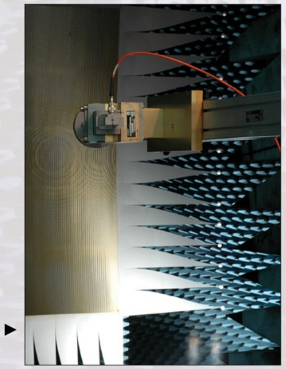


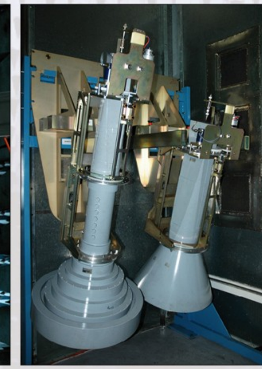


◄ **Réflecteur parabolique :**
5,3 m x 5,6 m, 48 tonnes.
- Focale : 13 m.
- Etat de surface : 25 µm RMS,
- Zone tranquille maximale de 4 m x 4 m x 4 m.

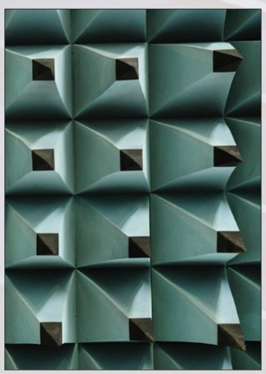
15 sources primaires ►
de 0,4 à 200 GHz.

Simuler la liaison bord sol





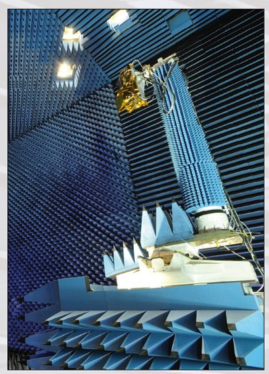
Isoler l'antenne dans l'espace



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

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

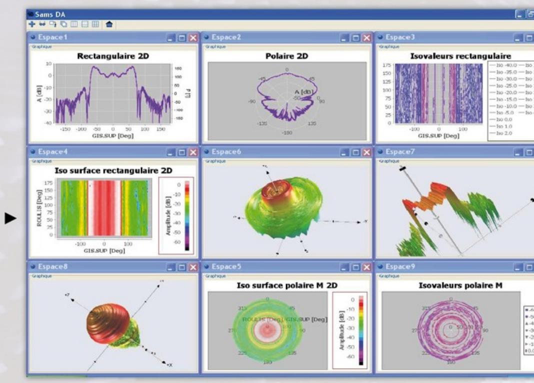
Positionner l'antenne dans l'espace



◄ 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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CENTRE NATIONAL D'ÉTUDES SPATIALES

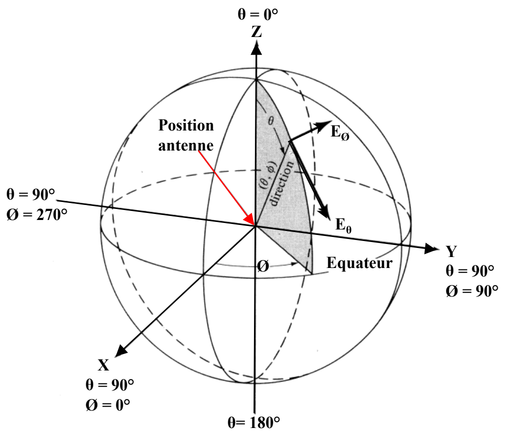
Analysis of dispersion w.r.t. azimuth angle first analysis (1/2)

- 9 antennas analyzed
- Usual analysis performed by the CNES antenna department give :

  Measurements for :

  4 plans (4 azimuth angle): ϕ = 0°, 45°, 90°, 135°

  with θ going from -180 to 180°



- We can get 8 samples of azimuth measurements:
  - ϕ = 0°; 0<θ< 90
  - ϕ = 45°; 0<θ< 90
  - ϕ = 90°; 0<θ< 90
  - ϕ = 135°; 0<θ< 90
  - ϕ = 0°; 0>θ>- 90 => ϕ = 180°; 0<θ< 90
  - ϕ = 45°; 0>θ>- 90 => ϕ = 225°; 0<θ< 90
  - ϕ = 90°; 0>θ>- 90 => ϕ = 270°; 0<θ< 90
  - ϕ = 135°; 0>θ>- 90 => ϕ = 315°; 0<θ< 90

- For each antenna, we calculate :
  - » For a given couple (ϕ; θ) :
  - » **φ - ϕ - φcorrection (θ)**

    With : φ : phase measurement

    ϕ : azimuth angle

    φcorrection (θ) : phase law correction

  - » **To eliminate dispersion in θ**
  - » **we determinate the mean value over θ**

=> We obtain a azimuthal dispersion for each antenna