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INSTITUT NATIONAL  
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CENTRE NATIONAL D'ÉTUDES SPATIALES



# Ground Antenna Position Initiating an Error Budget

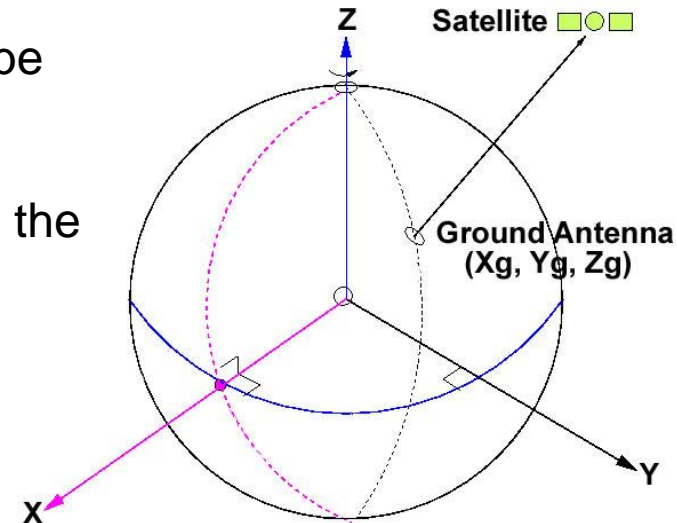
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## ■ OBJECTIVE

- The DORIS system measures distances between phase centers of onboard and ground antennas to determine the satellite position on its orbit

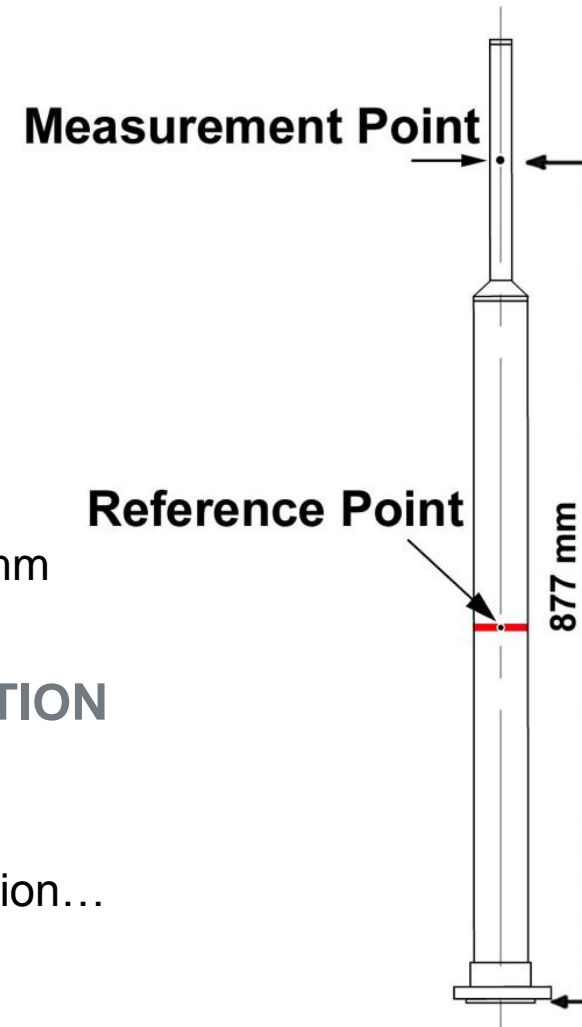
## ■ REQUIREMENT

- The ground antenna phase center position must be known in a terrestrial reference frame
- This position is linked and defined with respect to the Antenna Reference Point (ARP), a conventional physical point of the antenna body

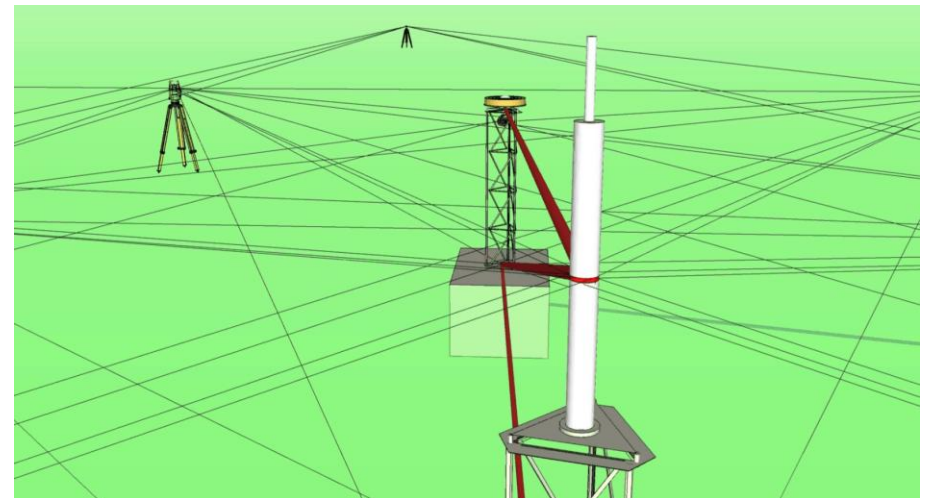
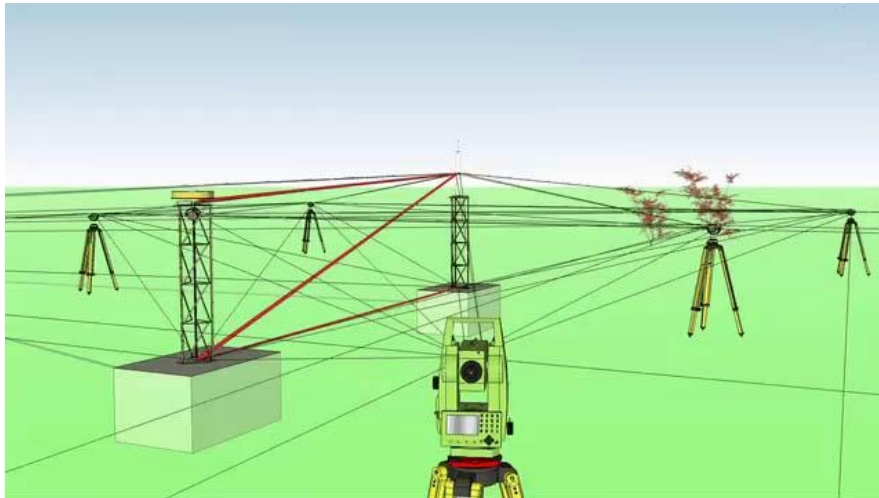


# THE GROUND ANTENNA

- STAREC MODEL: HELICAL ANTENNA TYPE
- THE ENTIRE NETWORK USES THIS ANTENNA
- ANTENNA REFERENCE POINT (ARP):
  - Intersection of the antenna axis and the red ring
- ACTUAL MEASUREMENT POINT (AMP):
  - 2GHz phase center: located on the antenna axis, 877 mm from the antenna base
- THE AMP POSITION IS DEFINED W.R.T. ARP POSITION
  - Up Eccentricity of 487 mm between ARP and AMP
  - Possible manufacturing defect: misalignment, imperfection...
  - Possible installing defect: verticality



- **PLACE UP RIGHT THE ANTENNA: VERTICALITY ADJUSTMENT**
  - Meet the installation specifications to secure the link between ARP and AMP
- **ASSIGN COORDINATES TO THE ANTENNA REFERENCE POINT**
  - Combining terrestrial measurements of angles, distances and height differences
  - Computing differential coordinates expressed in a topometric frame
  - Referencing into a global frame (ITRF)

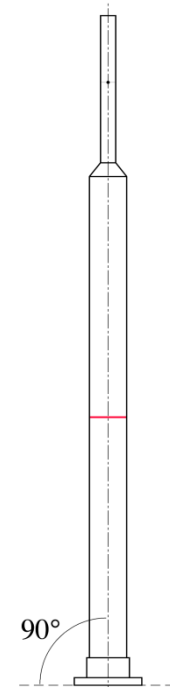
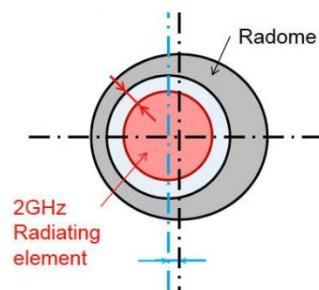


## ■ MANUFACTURING

1. Variability of the 2GHz phase center position w.r.t. antenna flange => vertical error
2. Centering of the 2GHz phase center w.r.t. radome => horizontal error
3. Alignment ARP/AMP w.r.t. antenna axis => horizontal error
4. Perpendicularity of the antenna flange w.r.t. antenna axis => cured by installation

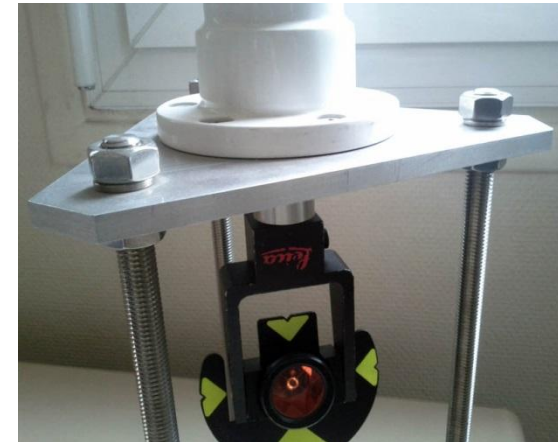
## ■ SURVEY

1. Antenna verticality adjustment => horizontal error
2. Local tie survey (ARP positioning) => horizontal and vertical error



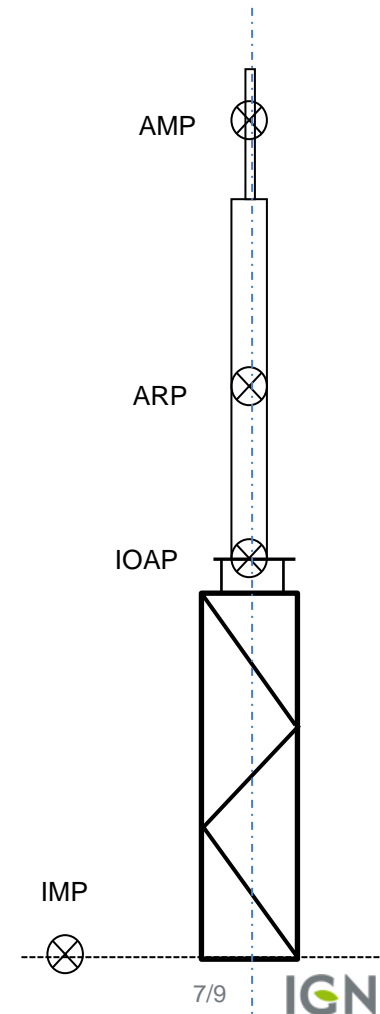
# WORKING GROUP CNES/IGN

- **NEW ANTENNA DEVELOPMENT: NOT THE OPTION RETAINED**
- **MAKING IMPROVEMENTS TO THE CURRENT ANTENNA**
  - Antenna characterization undertaken by CNES
  - Better control of the reproducibility of the antennas manufacturing
  - Thinking on devices facilitating the survey
  - Defining the characteristic points of the antenna
- **STAREC B TYPE => STAREC C TYPE**
  - From serial number SN 172
  - Consolidated specifications :
    - Position of the 2GHz phase center w.r.t. antenna body
    - Perpendicularity antenna base/antenna axis
    - Alignment of the connector on the antenna axis
  - Allows new method of ARP position determination



# ANTENNA POINTS DEFINITIONS\*

- **AMP: ACTUAL MEASUREMENT POINT**
  - 2 GHz phase center
- **ARP: ANTENNA REFERENCE POINT**
  - Intersection of the antenna axis and the red ring
- **IOAP: INSTRUMENT OPTICAL ACCESS POINT**
  - Intersection of the antenna axis and the flange
  - Can be surveyed directly (optically)
- **IMP: INSTRUMENT MONUMENT POINT**
  - Witness mark under the antenna = geodetic print of DORIS
  - Essential to measure successive antenna positions
  - Measured using surveying techniques

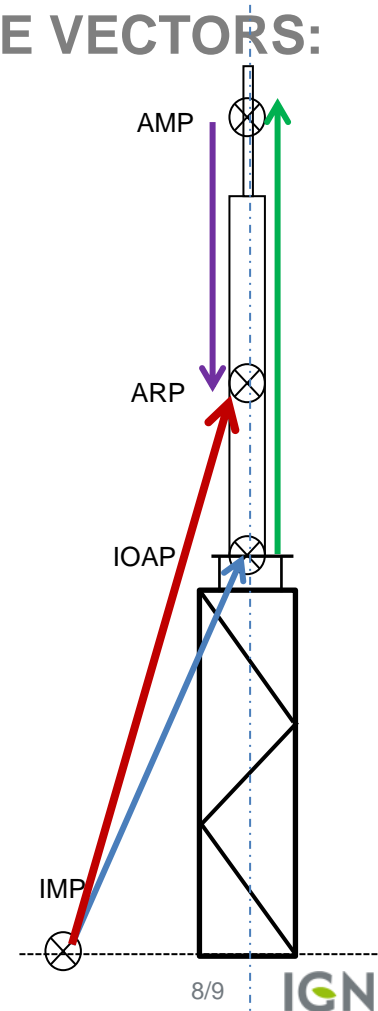


\* *Inspired by the Space Geodetic Project (NASA) nomenclature*

# VECTORS

- IF THE ANTENNA REQUIREMENTS ARE MET (MANUFACTURING + INSTALLING) :
- WE CAN DETERMINE THE ARP POSITION USING THESE VECTORS:
- **IMP > IOAP**
  - Determined by optical surveys
- **IOAP > AMP**
  - Up Eccentricity of 877mm
- **AMP > ARP**
  - Up Eccentricity of -487mm

$$\text{IMP} > \text{ARP} = \text{IMP} > \text{IOAP} + \text{IOAP} > \text{AMP} + \text{AMP} > \text{ARP}$$





# ERROR BUDGET



- The work with the manufacturer helped to consolidate the antenna specifications and draw up an error budget
- The topometric measurement uncertainties remain unchanged but the surveying operations are facilitated

Error Type	Error Source	Direction	Error Value	
Manufacturing	2GHz PC centering / radome	Horizontal	± 1 mm	± 2 mm
Manufacturing	Alignment ARP/AMP / axis	Horizontal	± 1 mm	
Manufacturing	2GHz PC position / flange	Vertical	± 1 mm	± 3 mm
Characterization	2GHz PC position and associated phase law	Vertical	± 2 mm	
Survey	Verticality adjustment	Horizontal	± 1 mm	± 2 mm
Survey	Local tie survey	Horizontal	± 1 mm	
Survey	Local tie survey	Vertical	± 1 mm	± 1 mm

**NB**: this error budget is relating to future installations (C type antenna)