Estimation of the invariant reference point: first steps at Yebes

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Introduction
Why do we seek the IRP?

• In a geodetic VLBI experiment, the radiotelescope coordinates within a terrestrial frame are estimated for its IRP.

• The IRP of a radiotelescope is geometrically defined as the nearest point of the azimuth axis to the elevation axis.

• The physical realization of this point is a key issue to estimate the relative vector between VLBI and other space geodetic techniques.

• These tie vectors are currently essential for the construction of the ITRF.

The realization of the IRP is fundamental and beneficial for all geosciences using the ITRF.

Introduction
How to estimate the IRP?

• The IRP coordinates with respect to a local (observatory) coordinate system are indirectly estimated through survey observations to targets located on the radiotelescope.

• Usually, survey observations are performed from a dense control network, by an experienced surveyor team, and using several high-quality instruments.

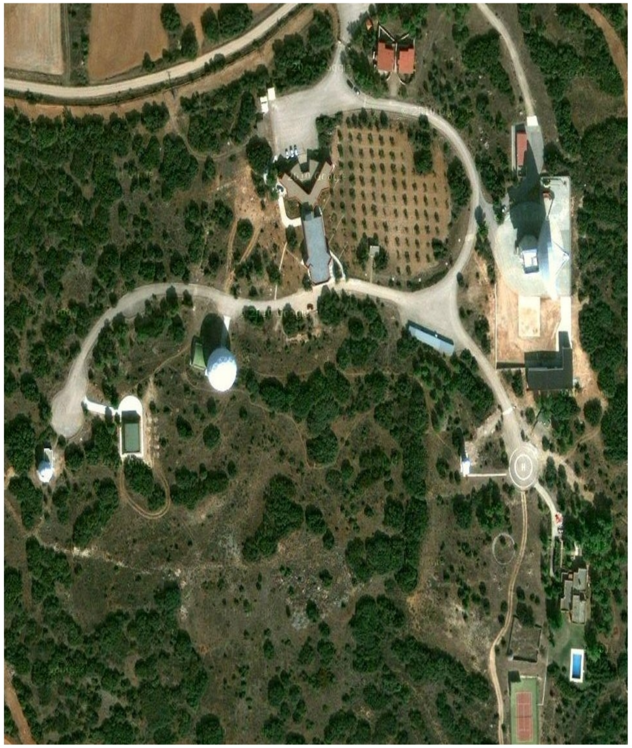
• The current approach being developed at the Yebes observatory is based on **automated**, **unmanned**, **remote-controlled** and **continuous** survey observations with a few instruments.

The purpose of this talk is to show the results of a simulation study based on this approach

Outline

- The Yebes observatory
- The IRP estimation
- Simulation
- Results
- Conclusions and Steps forward

The Yebes observatory



Want to see more?
Do not miss the visit on Wednesday afternoon!

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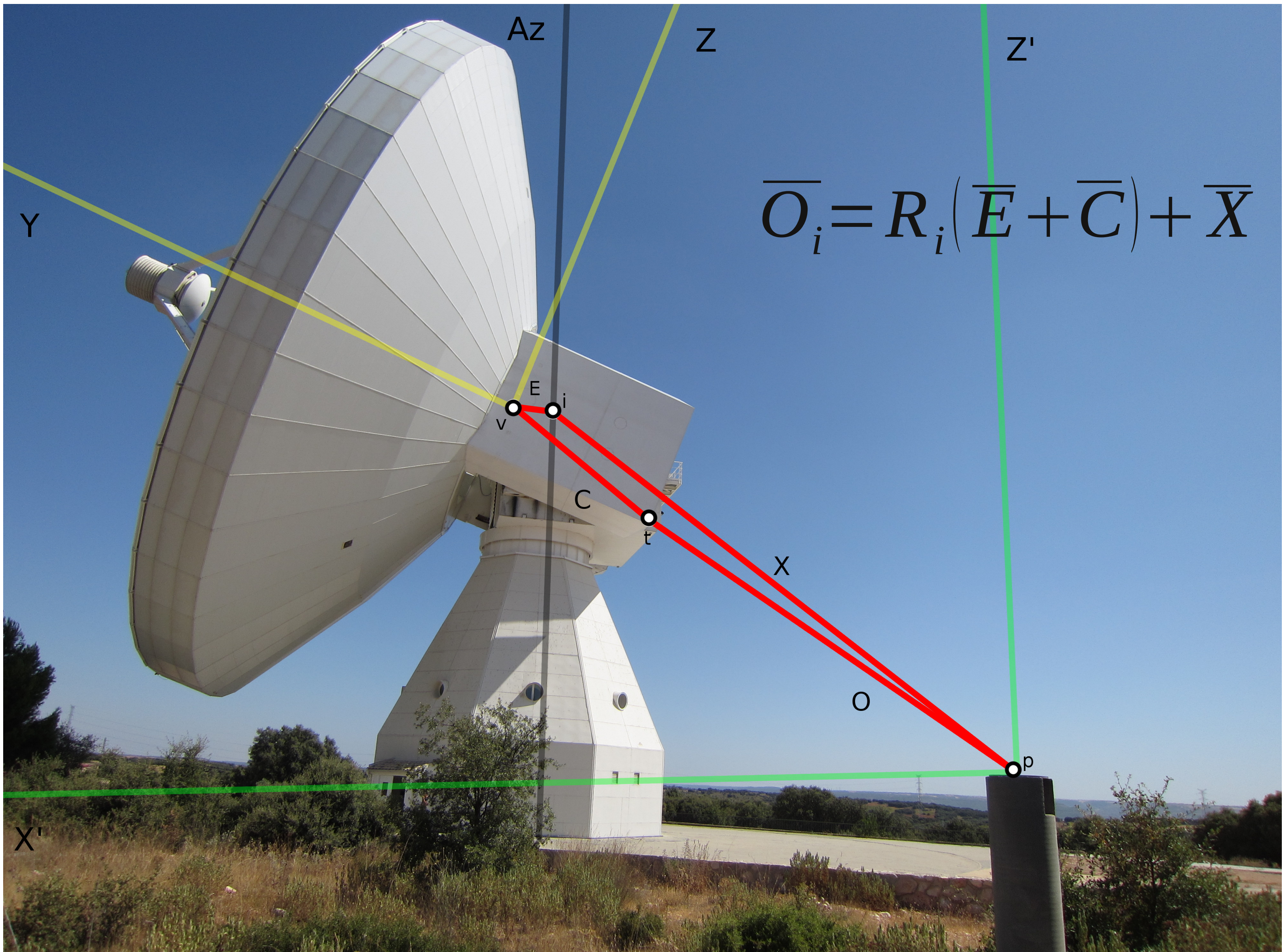
The IRP estimation



Outline

- The Yebes observatory
- The IRP estimation
- **Simulation**
  - Objectives
  - Procedure
- Results
- Conclusions and Steps forward

Simulation
Objectives

- **The number of observations (= radiotelescope orientations).**

Is it enough to use the radiotelescope orientations of a current 24h VLBI experiment in Yebes?

Simulation
Objectives

- The number of observations (~ radiotelescope orientations).
- **The number of the observing instruments.**

Is it enough to use only one observing instrument? (the cheapest solution).

How much the precision is improved with additional observing instruments?

Simulation
Objectives

- The number of observations (~ radiotelescope orientations).
- The number of the observing instruments.
- **The precision of the survey observations.**

Is the precision of the automated observing instruments enough to estimate the IRP coordinates better than 1mm?

How many observations should we integrate to minimize the survey errors?

Simulation
Procedure

- **The targets on the radiotelescope.**

Two targets were simulated to be located on both counterweights since they are less prone to deformation.

The coordinates of the targets in the radiotelescope system were extracted from the construction plans.

Simulation
Procedure

- The targets on the radiotelescope.
- **The radiotelescope orientations.**

Set of simulated orientations: 100, 400, 700 and 1000 ``homogeneously`` distributed.

Up to now the largest VLBI experiment in Yebes has ~400 observed sources (~ orientations).

The maximum number of orientations the Yebes RT could ever have in 24h is ~1000.

Simulation
Procedure

- The targets on the radiotelescope.
- The radiotelescope orientations.
- **The observing instruments.**

One, two and three observing instruments were simulated separated by 120° in azimuth from the radiotelescope.

The distance to the instruments was simulated by the precision of the field observations (assuming observation errors being proportional to the distance).

Simulation
Procedure

- The targets on the radiotelescope.
- The radiotelescope orientations.
- The observing instruments.
- **The survey observations.**

$$\overline{X}+\left(\overline{E}+\overline{C}\right)R_i=\overline{O}_i$$

All parameters to be estimated (IRP coordinates, axes offset, inclination and orthogonality) were set to zero.

We took into account the occultation of the targets behind the dish.

Simulation
Procedure

- The targets on the radiotelescope.
- The radiotelescope orientations.
- The observing instruments.
- The survey observations.
- **The random errors.**

White noise of 3, 6, 9, 12 and 15 mm std. dev. added to the observed targets in the observatory system and to the target coordinates in the RT system.

The simulated errors included survey errors and coordinate system errors (radiotelescope and observatory).

Simulation
Procedure

- The targets on the radiotelescope.
- The radiotelescope orientations.
- The observing instruments.
- The survey observations.
- The random errors.
- **Repeating 1000 times.**

For the estimated parameters in each scenario:

mean = bias
standard deviation = precision

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Results
Precision of the IRP coordinates

One observing instrument: 3D precision in mm.

#Obs \ Error	3	6	9	12	15
1000	**0.5**	0.9	1.4	1.8	2.3
700	**0.5**	1.1	1.6	2.2	8.6
400	0.7	1.5	2.2	2.9	3.6
100	1.4	2.7	4.1	5.5	7.2

Results
Precision of the IRP coordinates

Two observing instrument: 3D precision in mm.

#Obs \ Error	3	6	9	12	15
1000	**0.2**	**0.4**	0.6	0.8	1.0
700	**0.2**	**0.5**	0.7	0.9	1.2
400	**0.3**	0.6	0.9	1.2	1.5
100	0.6	1.2	1.8	2.4	3.0

Results

Precision of the IRP coordinates

Three observing instrument: 3D precision in mm.

#Obs \ Error	3	6	9	12	15
1000	**0.2**	**0.3**	**0.4**	0.6	0.7
700	**0.2**	**0.4**	**0.5**	0.7	0.9
400	**0.2**	**0.5**	0.7	1.0	1.2
100	**0.5**	0.9	1.3	1.8	2.3

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Conclusions

<u>One observing instrument</u>: high precise field observations and more orientations than in a current 24h VLBI experiments in Yebes, **but it might be still possible!**

<u>Two observing instruments</u>: IRP precision is improved by ~60%. The requirements of number of orientations and observation precision are considerably reduced, but **current 24h VLBI experiments might be still not enough for Yebes!**

<u>Three observing instruments</u>: IRP precision is improved by ~70%. **Current 24h VLBI experiments are likely enough for Yebes!**

Best solution?
Precision (Poster 2.14) vs Economy (each instrument ~30K €)
Faster RT (VLBI2010) ~ more orientations = **cheaper solution!**

Steps forward
Chronologically

- To develop the IRP estimation approach, e.g. by adding the thermal deformation correction (included in IVS analysis).

- To test the estimation method with real data from other RT
  OSO has already provided us with some data but no conclusive results were obtained yet.

- To perform several tests of the instruments performance
  - precision and accuracy of real observations
  - quality of targets

- To introduce a local tie survey system based on this approach in the Yebes observatory


Questions?
Suggestions?
Carlos Albo