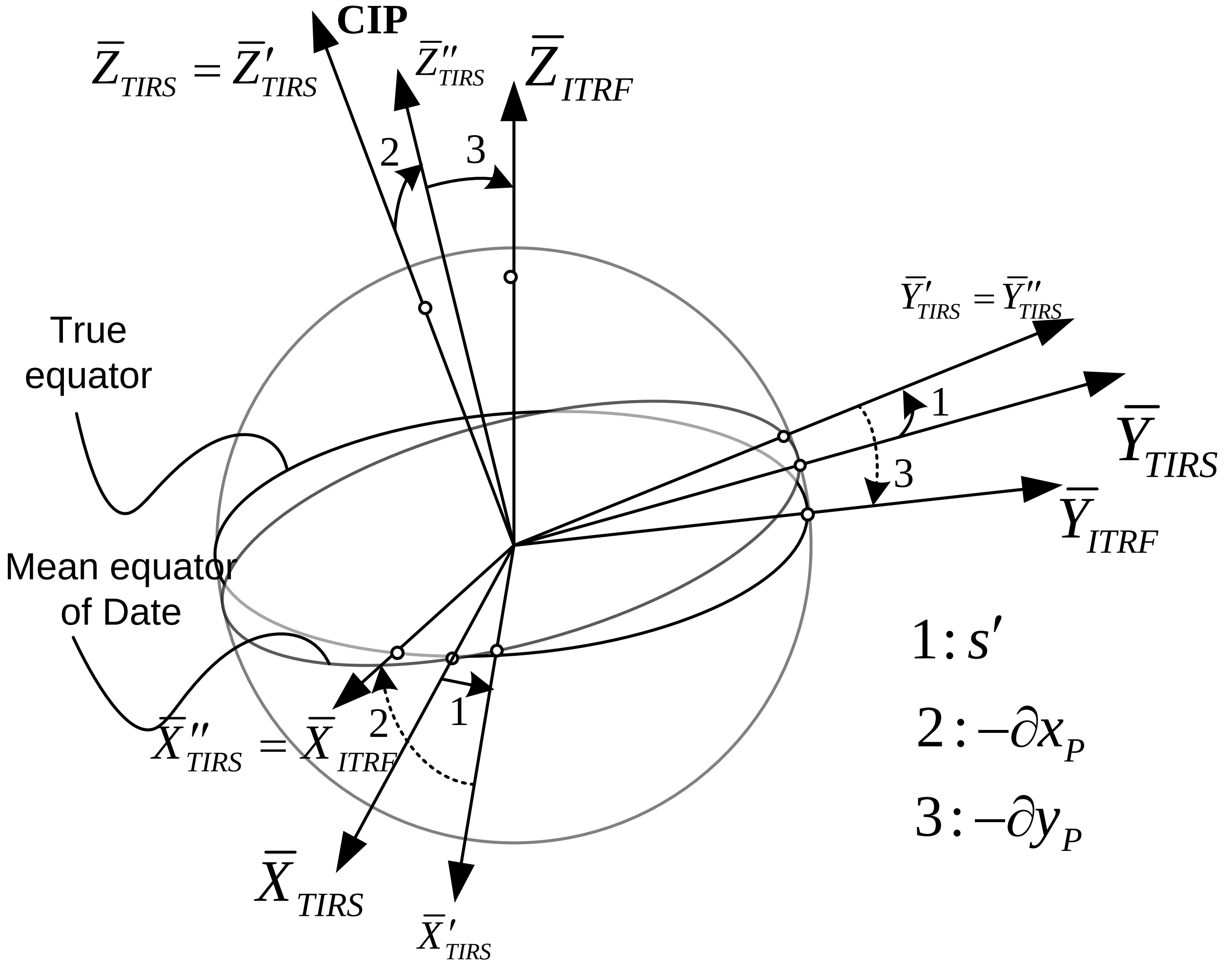
Moscow Aviation Institute (National Research University)

EARTH ROTATION PARAMETRES ESTIMATION USING BOTH RANGE-ON REQUEST AND PSEUDORANGE MEASUREMENT DATA

D.A Kozorez   M.N. Krasilshchikov
D.M. Kruzhkov

Basic Concept :
TIRS to ITRF conversion by given date



Procedures:

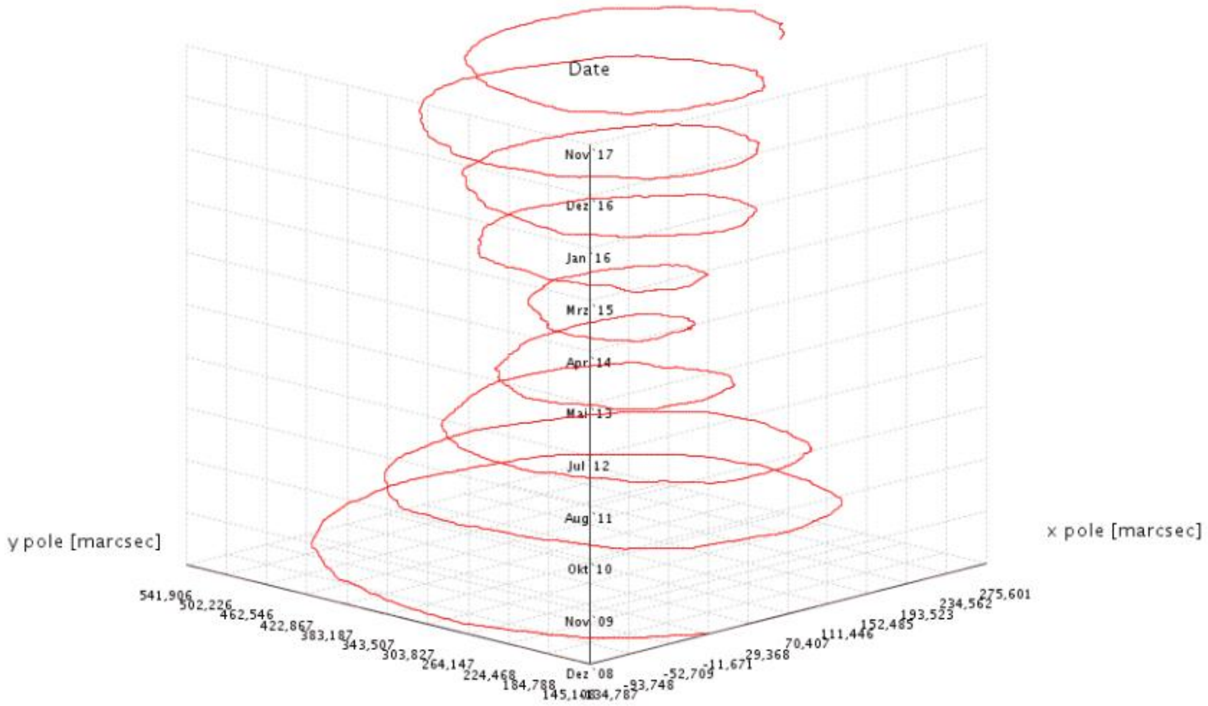
- Celestial intermediate pole position definition in TIRS due to GCRS –> TIRS conversion by precession and nutation matrixes;
- Refinement of X_{TIRS},Y_{TIRS} attitude due to Earth rotation angle (ERA) calculation (time since J2000);
- Refinement of ITRF axes attitude by s', then (-xp) and (-yp).

Usage: need to consider at any GNSS output
Otherwise navigation accuracy loss up to 20 meters

$$\mathbf{A}_X\left(-\partial Y_p\right)=\begin{pmatrix}1 & 0 & 0\\ 0 & \cos\left(\partial y_p\right) & -\sin\left(\partial y_p\right)\\ 0 & \sin\left(\partial y_p\right) & \cos\left(\partial y_p\right)\end{pmatrix},\mathbf{A}_Y\left(-\partial x_p\right)=\begin{pmatrix}\cos\left(\partial x_p\right) & 0 & \sin\left(\partial x_p\right)\\ 0 & 1 & 0\\ -\sin\left(\partial x_p\right) & 0 & \cos\left(\partial x_p\right)\end{pmatrix},$$

$$\mathbf{A}_Z\left(s'\right)=\begin{pmatrix}\cos\left(s'\right) & \sin\left(s'\right) & 0\\ -\sin\left(s'\right) & \cos\left(s'\right) & 0\\ 0 & 0 & 1\end{pmatrix},D_{ITRF}\left(Satellite,Station\right)=f\left(\mathbf{A}_X,\mathbf{A}_Y,\mathbf{A}_Z,D_{GCRS}\right)$$

Basic problems by pole position refinement

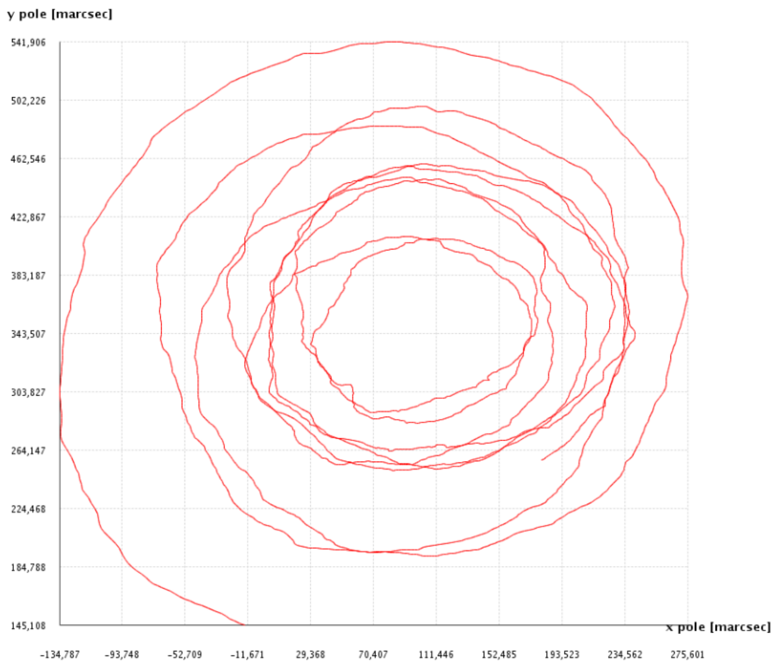


Complexity of pole position propagation using actual mathematical models due to

- Fast on – line xp, yp and s parameters evolution
- Exisiting both ~430 days and short-time period harmonics

Solution:

- Laser ranging and very long base interference data fusion



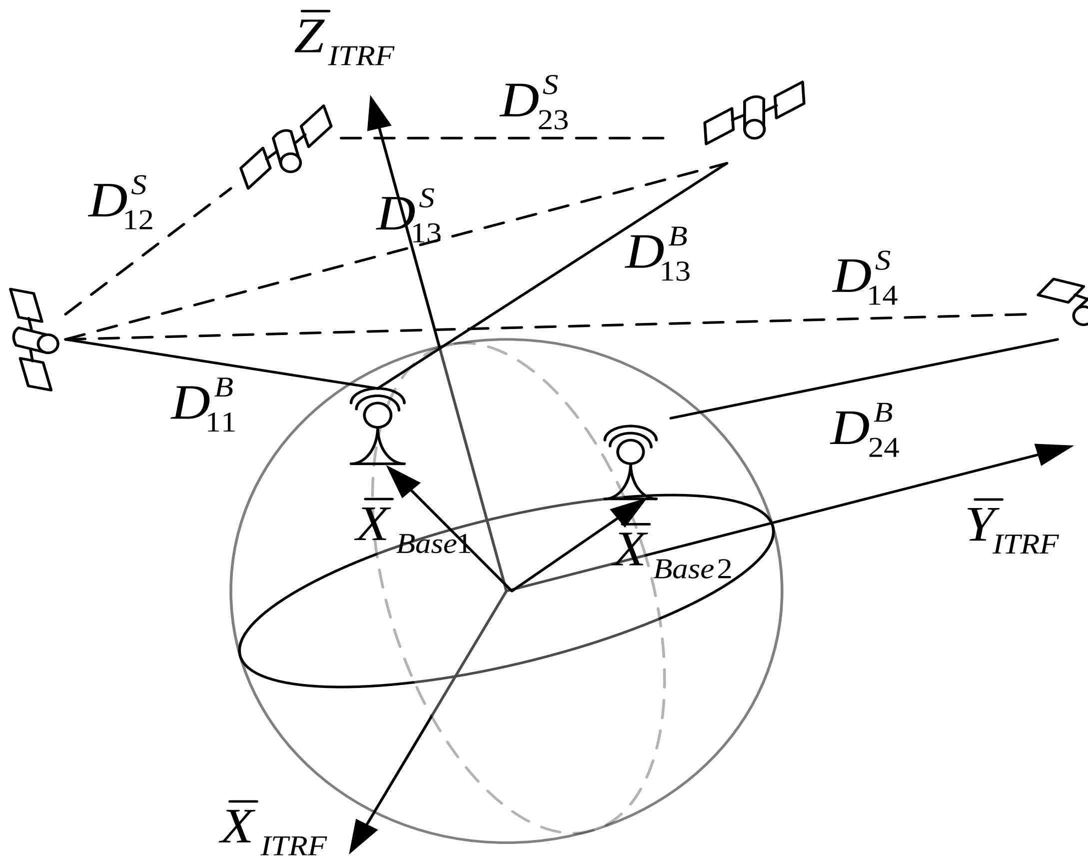
Potential data sources:

- IERS (provided with rapid and accurate bulletins)

Actual data utilization:

- Daily pole position refined data GNSS satellites onboard downloading

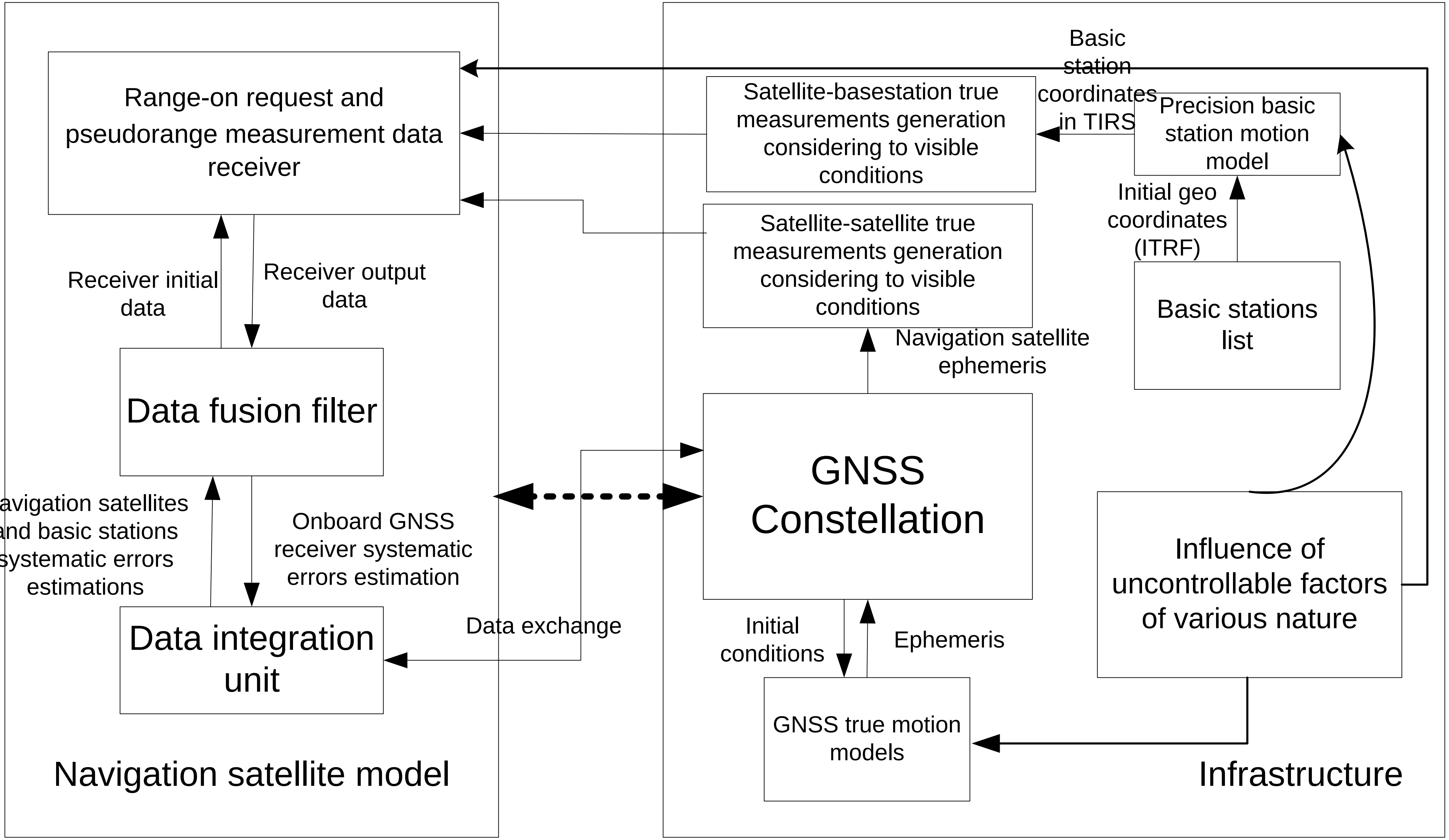
Autonomous pole coordinate estimation



Basic approach:
Pole motion parameters estimation using both satellite-satellite & satellite-on ground basic station measurement data, considering the fact of independency GNSS satellites motion from actual pole position (in short time period)

Result:
- Pole position refinement is completed online by onboard calculating Procedure*
- Autonomous GNSS operation is provided
- Pole position refinement data can be distributed to other satellite of working constellation

Simplified diagram of autonomous pole position estimation Procedure* implementation



Hardware & software complex components

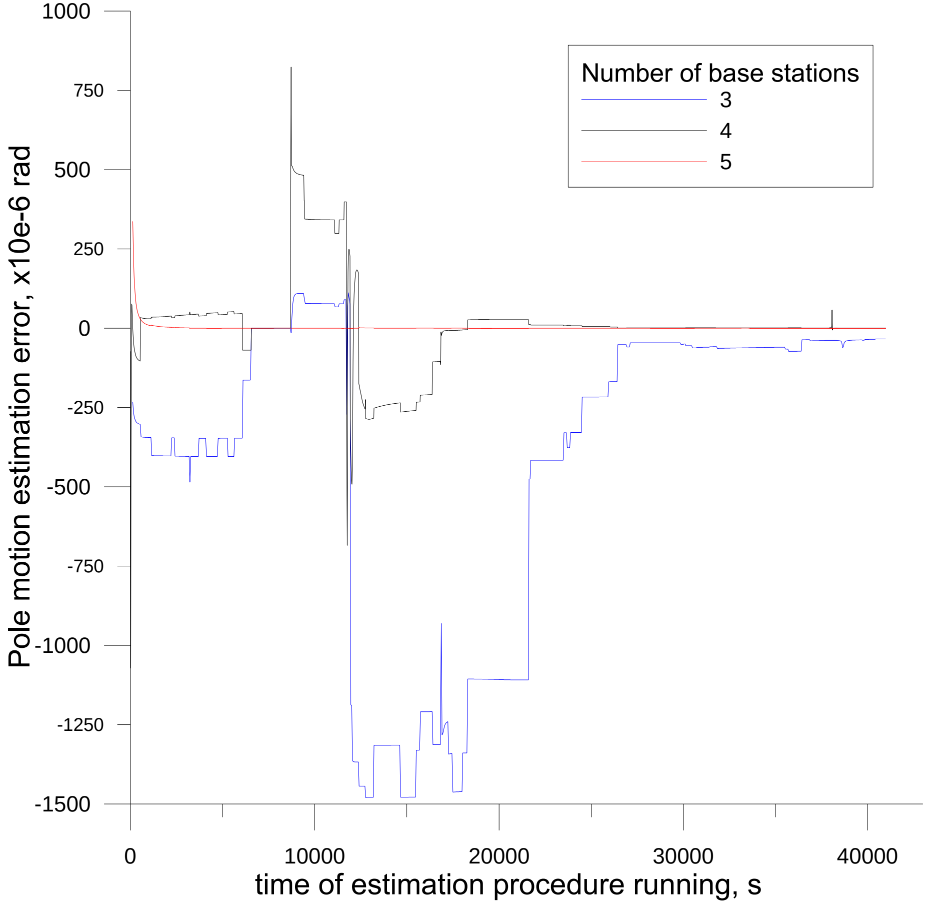
High accurate satellite motion model:
- EGM 2008 (2196 harmonics)
- Moon and Sun gravity
- Solar pressure
- Albedo

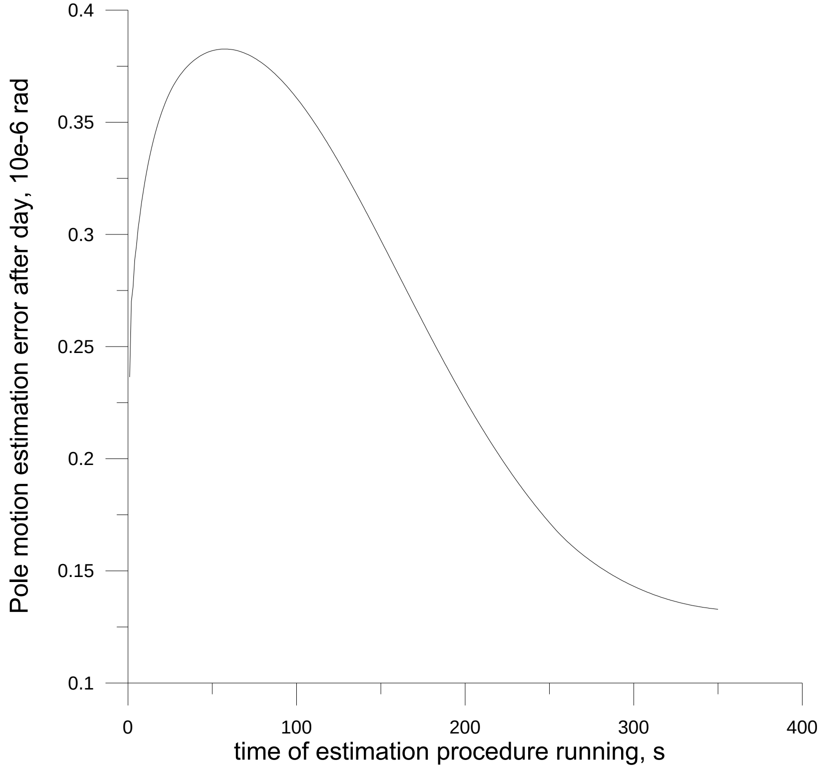
High accurate measurement model:
- Troposphere and Ionosphere delays
- Time scale delays
- Earth plate model
- All general receiver errors

Filtering:
- Pseudo scalar Kalman filtering
- Root mean square

Hardware complex:
- GNSS constellations imitator
- Topcon receiver

Potential accuracy pole position estimation by simulation & actual data processing results





- Rapid estimation procedure gives accuracy about few meters (3 RMS) on Earth geoid surface
- Long estimation procedure allows to reach estimation accuracy till to 1 meter (3 RMS)