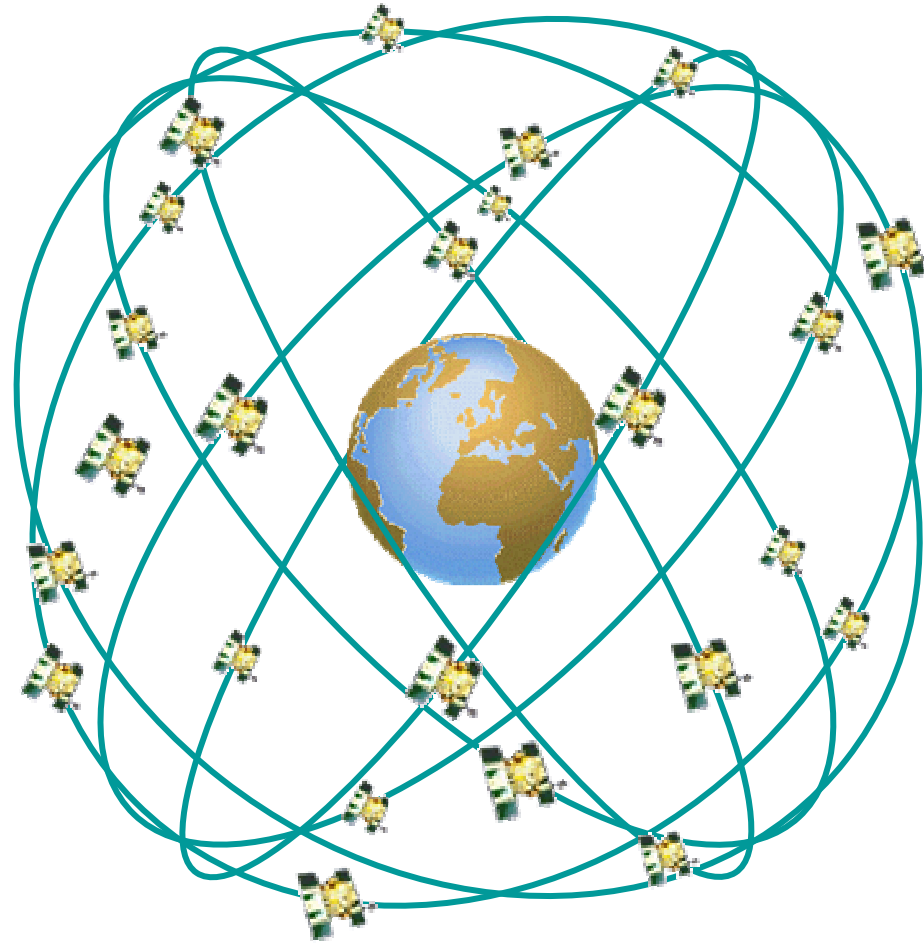


# GPS Synchronized Rubidium

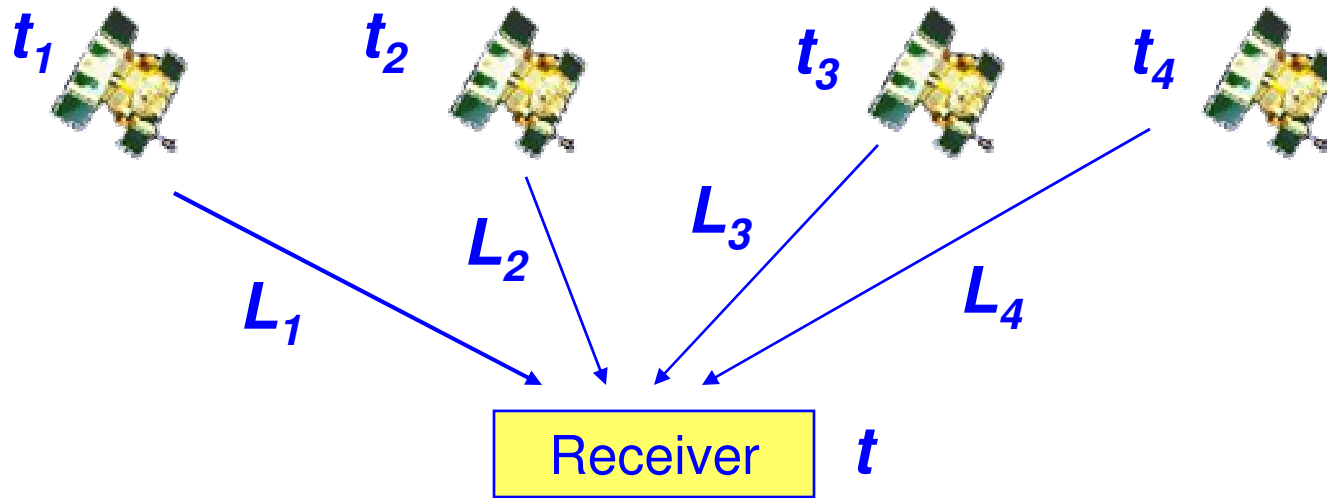
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# Global Positioning System (GPS)



**GPS Nominal Constellation:**  
**24 satellites in 6 orbital planes,**  
**4 satellites in each plane,**  
**20,200 km altitude, 55 degree inclinations**

# GPS Principles



$$L_1 = c (t - t_1) = \sqrt{(x-x_1)^2 + (y-y_1)^2 + (z-z_1)^2}$$

$$L_2 = c (t - t_2) = \sqrt{(x-x_2)^2 + (y-y_2)^2 + (z-z_2)^2}$$

$$L_3 = c (t - t_3) = \sqrt{(x-x_3)^2 + (y-y_3)^2 + (z-z_3)^2}$$

$$L_4 = c (t - t_4) = \sqrt{(x-x_4)^2 + (y-y_4)^2 + (z-z_4)^2}$$

4 equations, 4 unknowns

Solution  $\Rightarrow x, y, z, t$  of the receiver.

# GPS

GPS can provide global, all-weather, 24-hour, real-time, accurate navigation and time reference to an unlimited number of users.

- **GPS Accuracies ( $2\sigma$ )**

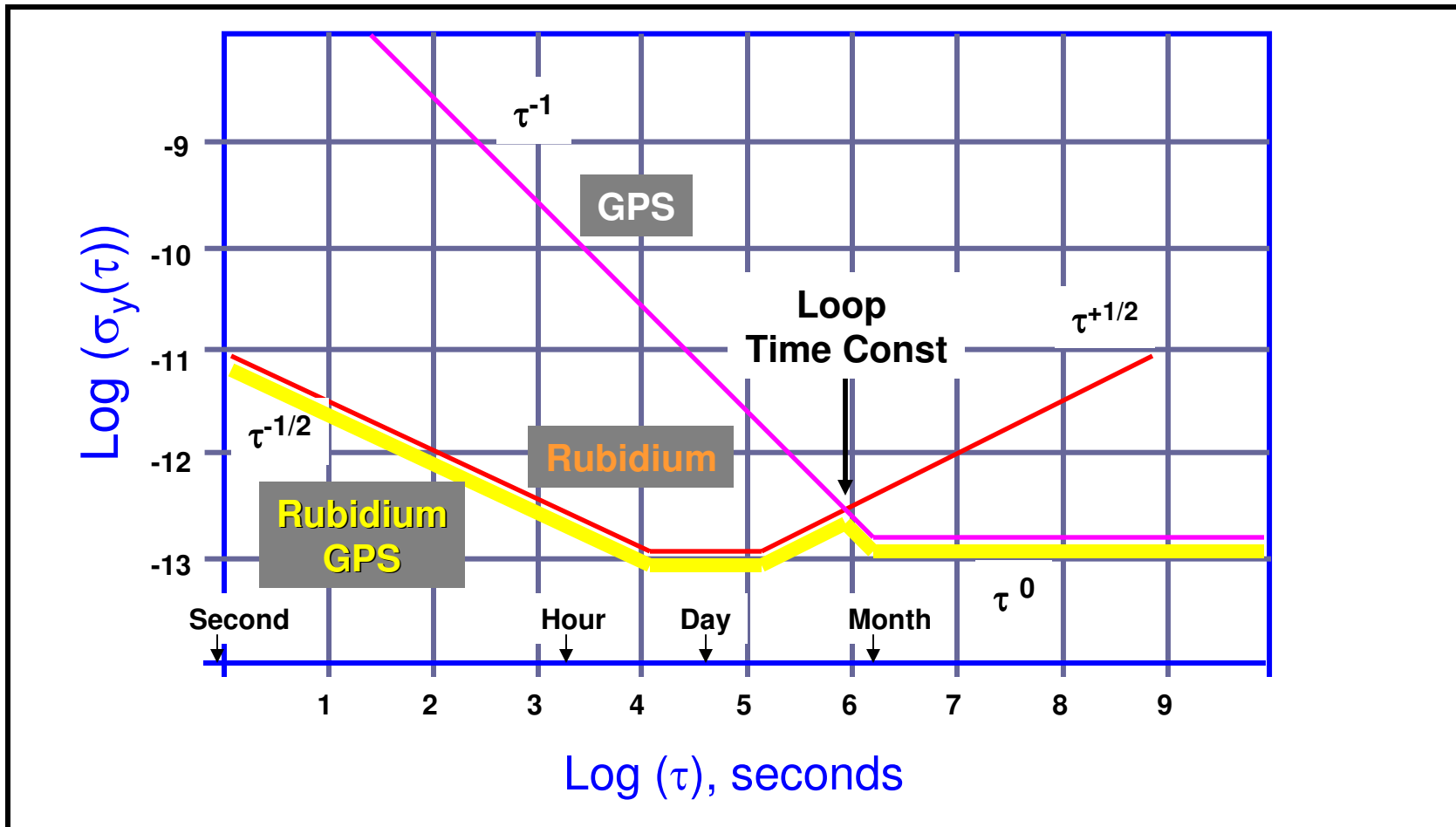
**Position:** 120 m for Standard Positioning Service, SPS  
40 m for Precise Positioning Service, PPS  
1 cm + 1ppm for differential, static land survey

**Velocity:** 0.3 m/s (SPS), 0.1 m/s (PPS).

**Time:** 350 ns to < 10 ns

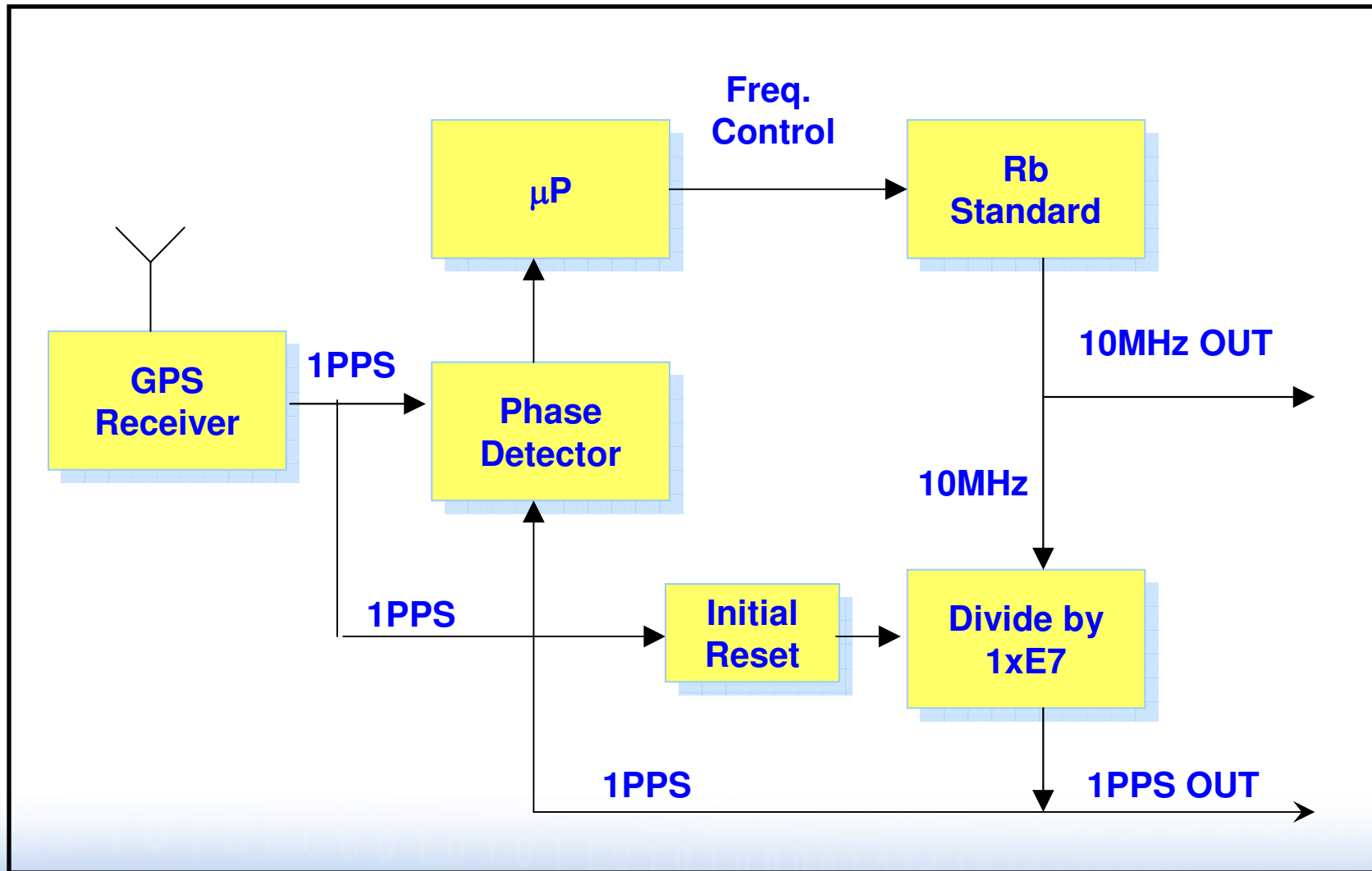
- 24 satellites in 6 orbital planes; 6 to 10 visible at all times; ~12 h period  
20,200 km orbits.
- Pseudorandom noise (PRN) navigation signals are broadcast at L1 = 1.575 GHz (19 cm) and L2 = 1.228 GHz (24 cm); two codes, C/A and P are sent; messages provide satellite position, time, and atmospheric propagation data; receivers select the optimum 4 (or more) satellites to track. PPS (for DoD users) uses L1 and L2, SPS uses L1 only.

# GPS-Rb Allan Deviation



For times shorter than the Loop Time Constant the stability follows the Rubidium  
 For times longer than the Loop Time Constant the stability follows the GPS

# GPS-Rb PLL Diagram

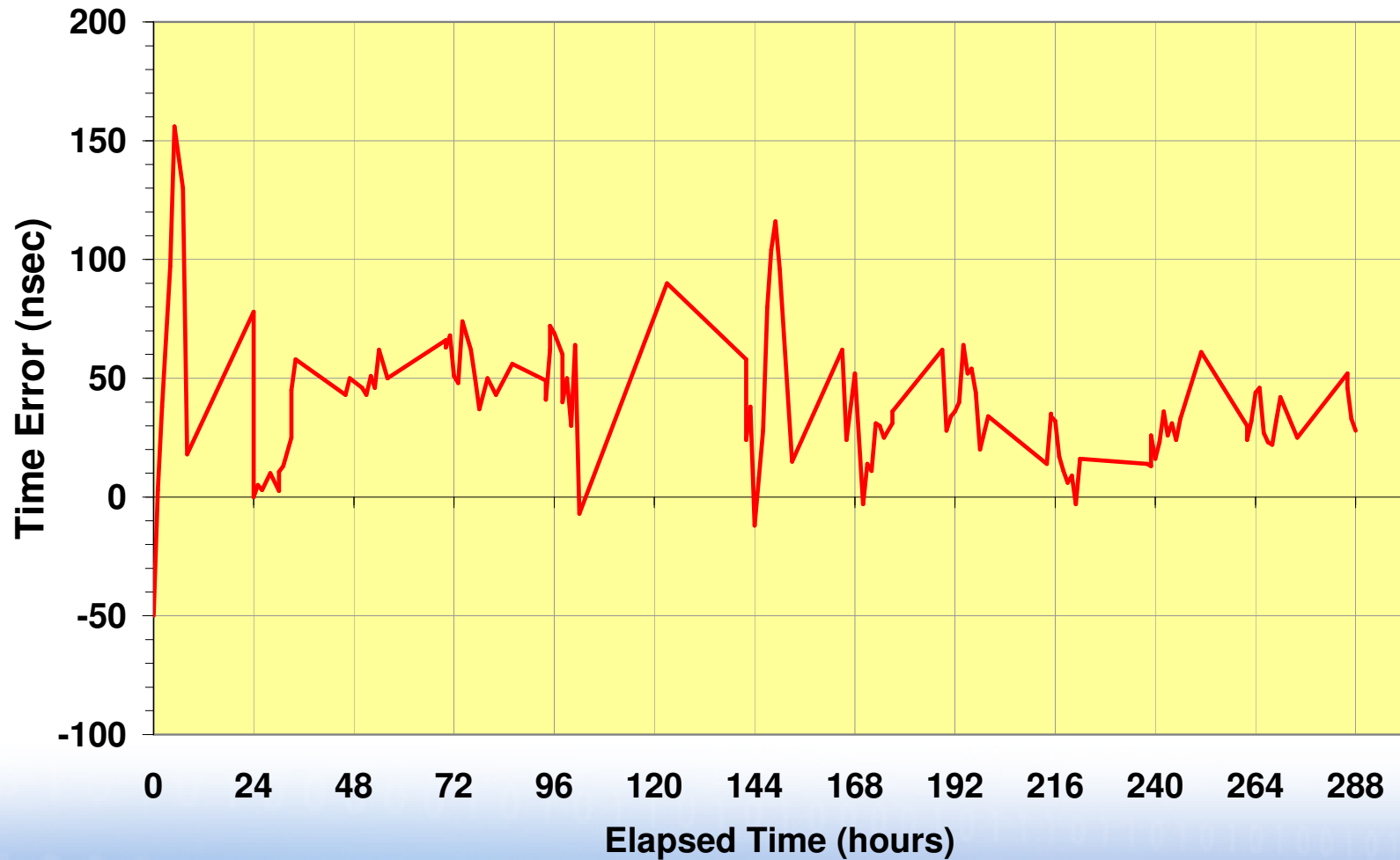


## Why Use GPS-Rb ?

- **Performance Comparable to a Cesium for **tenth** of the price**
- **Low dependency on GPS reception**
- **Long Hold Over: 1  $\mu$ s for 24 hours**

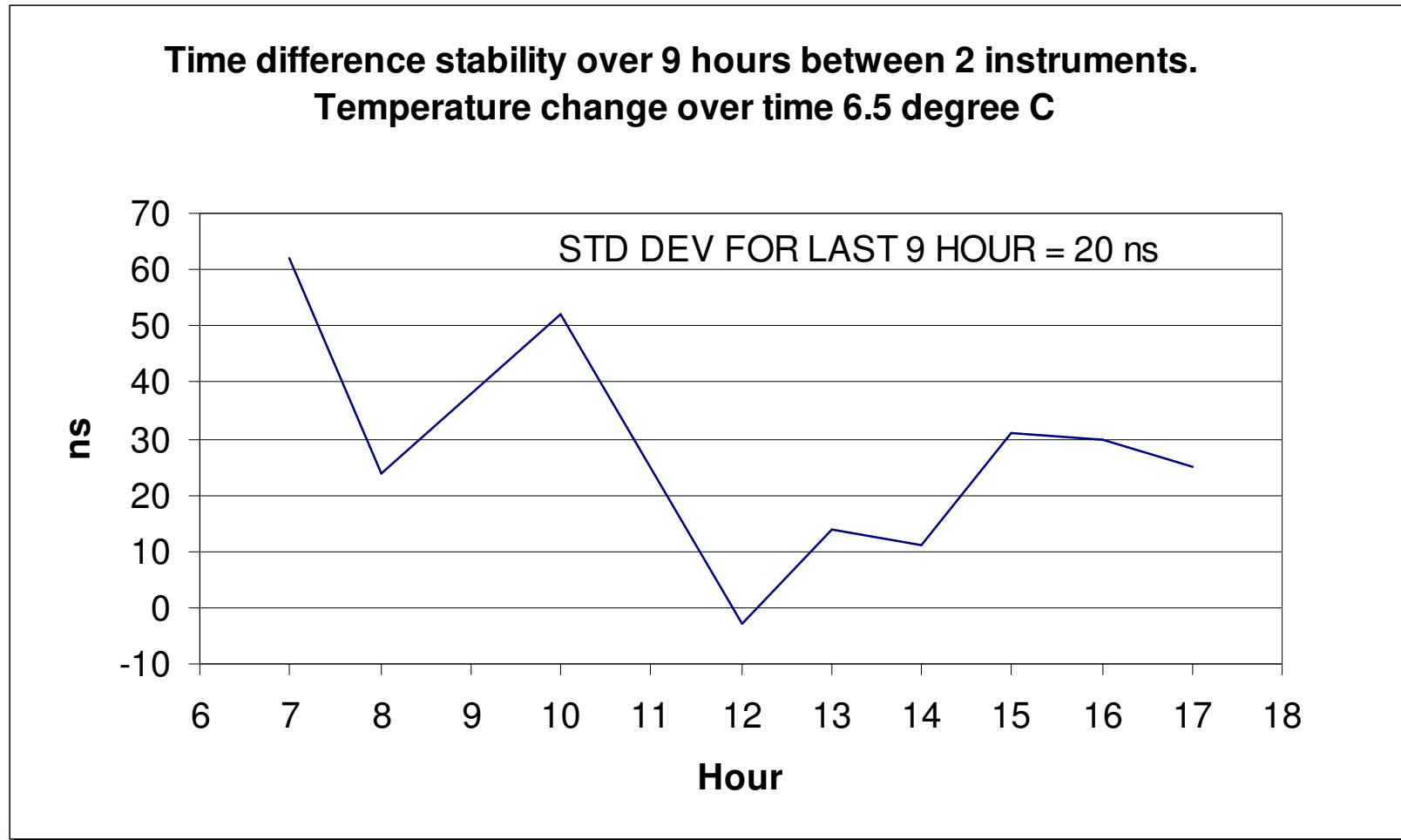
# Rb-GPS Performance Graphs

## Time Error AR-73A vs AR-73A





## Time difference between two AR73A unit



# Network Solution

