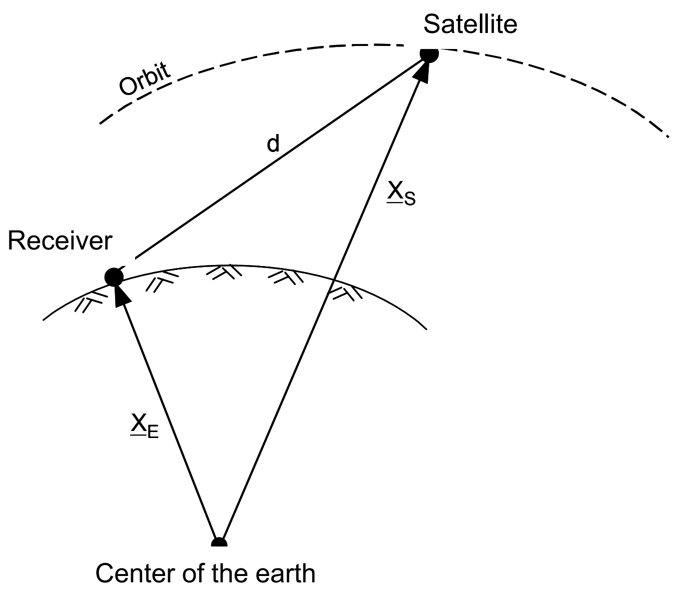
Lab 4:

Kinematic GNSS Measurements

Main Principle



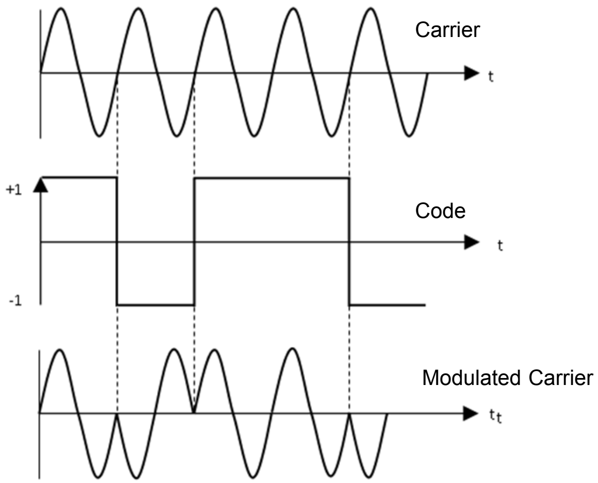
- Coordinates of satellite are known X_S
- d measurements are made by evaluating the transit-time between satellite and receiver
- Measuremets of distances d to different satellites
  → d defines a sphere surface around X_S
- X_E is the intersection point of 3 spheres
  (but: 4 satellites are needed in consideration of clock error)

Signals

Carrier waves

L1 : 154 × 10.23 MHz = 1575.42 MHz 19.05 cm
L2 : 120 × 10.23 MHz = 1227.60 MHz 24.45 cm

Codes



C/A-Code: course acquisition code on L1
Periode 1 msec
$f = f_0/10 = 1.023$ MHz 293.1 m
Noise (1%) of $\lambda \Rightarrow 3$ m)

P-Code: precise code on L1 und L2
Period 267 days (7 days per satellite)
$f = f_0 = 10.23$ MHz 29.31 m
Noise (1%) of $\lambda \Rightarrow 0.3$ m)

Data

- Phase modulation on L1 and L2
- Likewise sequence of +1 and -1
- Contains information about satellite‘s clock and position/ orbit
- 1500 bit at 50 bit/sec

Signal Processing

Code observations: measurements of pseudo ranges, falsification of distance by receiver‘s clock error

<u>Observation equation:</u>

$$\boxed{\rho_{rs} + v_{rs} = \sqrt{(X_s - X_r)^2 + (Y_s - Y_r)^2 + (Z_s - Z_r)^2} - c \cdot \delta T_r}$$

ρ_{rs} - Pseudo Range between receiver and satellite

v_{rs} - Correction

c - Speed of light

δT_r - Receiver‘s clock error (difference between receiver clock and GPS system time)

4 unknowns: $X_r \quad Y_r \quad Z_r \quad \delta T_r$ → at least 4 observations are needed

Signal Processing

Phase observations:

Observation equation:

$$\boxed{\rho_{rs} + v_{rs} = N \cdot \lambda + \frac{\lambda}{2\pi} \cdot \Delta\Phi_i = \sqrt{(X_s - X_r)^2 + (Y_s - Y_r)^2 + (Z_s - Z_r)^2} - c \cdot \delta T_r}$$

λ	- carrier wave length
N	- ambiguities, unknown number of full wavelengths
$\Delta\Phi_i = \Phi^R - \Phi_i^S$	- measured phase difference for satellite *i*

$$\Delta\phi_i(t_0) + \Delta\Delta\phi_i(t_0,t_1) + \Delta\Delta\phi_i(t_1,t_2) + \Lambda \; + \Delta\Delta\phi_i(t_{n-1},t_n) = \Delta\Phi_i(t_n)$$

Permanent satellite tracking and summation of phase differences.
N is unaltered, but unknown!

2 problems:
- unknown ambiguity *N* for each satellite
- cycle slips at tracking (loss of ambiguities)

solution:
- long observation times
- usage of more than 4 satellites
- usage of linear combinations of L1 and L2

Equipment

Leica Viva GS15

U-Blox

Phase Observations

Code Observations

Task

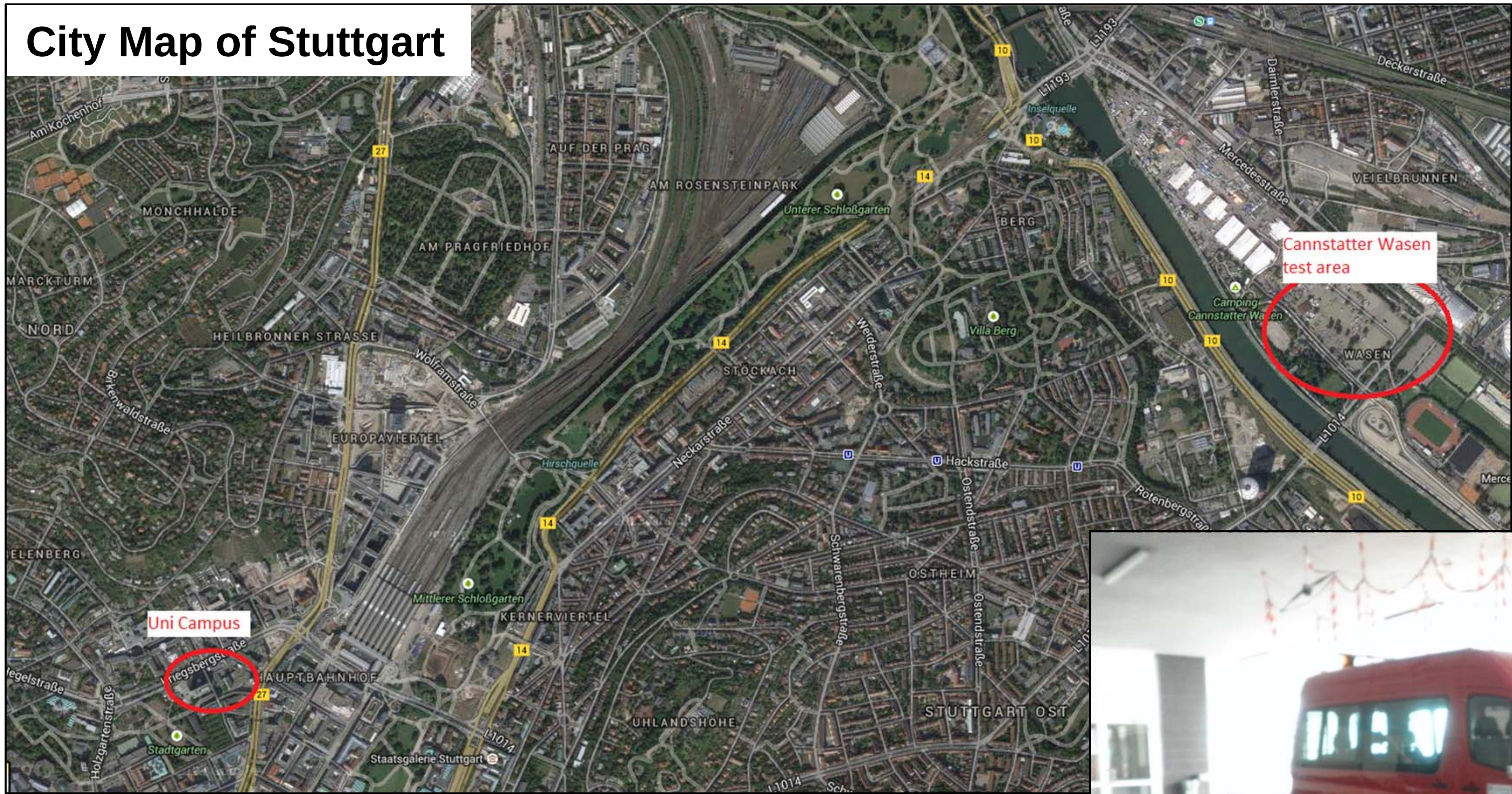
One member of each group has to join the test drives with the IIGS bus on the "Cannstatter Wasen". One member of each group has to do the data readout after testdrives.

The collected data should be processed as follows:

- **Calculation of the distance between the two antennas on the bus' roof**
- **Comparison of the calculated distances between the antennas with the "reference baseline" and plot of the differences for each epoch**
- **Plot of the driven trajectories for both GNSS receivers (in geodetic coordinate system $\lambda[°], \varphi[°], h[m]$)**
- **Calculation of the velocities for both receivers and their presentation in figures**
- **Plot of height differences between the two receivers**
- **Discussion on the results under following aspects:**

  - code solution
  - phase solution
  - shadowing areas

Measurement drives with the IIGS bus



Source: Google Earth

Dates+Times

Date	Students	Place	Time
Friday 15.06.2018	One member of each group	Cannstatter Wasen (Meeting Point: Institute bus in front of M24.01)	13:00-16:00
Monday 18.06.2018	One member of each group	IIGS CIP Pool	?