HACETTEPE UNIVERSITY
DEPARTMENT OF
GEOMATICS ENGINEERING

# GMT312 GLOBAL NAVIGATION SATELLITE SYSTEMS

## 2022-2023 Spring Semester

## Project

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| **Due date** | Tuesday, 15 June 2023, 11:59 PM |

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**Teaching Assistances:** Res. Asst. Müfide Er Elvanlı

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First of all, I gathered the inputs in one place as directed by our teacher Metin, then I entered the inputs of my final project as inputs in the same order as in the project introduction (You can see in Figure 1).

| | |
|---|---|
| **Measurements** | Only C1 (C/A) measurements of GPS satellites should be obtained from the related RINEX file. |
| **Satellite positions** | Final satellite positions should be calculated using precise ephemeris file (SP3) |
| **Satellite clock errors** | Satellite clock errors should be corrected using precise ephemeris file (SP3) |
| **Receiver position** | Approximate receiver position should be taken from the header of the observation file whenever needed. Final coordinates (XYZ) of the receiver should be estimated (in meters) |
| **Receiver clock error** | It should be estimated as an unknown parameter (in seconds). |
| **Ionospheric and Tropospheric delays** | They should be computed with the functions provided in Assignment#3, ("*Ion_Klobuchar*" and "*trop_SPP*".) |
| **Total Group Delay (TGD)** | It should be obtained from navigation data. |

```
last_project(C1,SP3,doy,trec,trecw,rec,alpha,beta,TGD)
```

*Figure 1 : Related Inputs*

**Note:** To run my code, you must first "RUN" the "all_input" matlab file. Then, at the bottom of my code, "Command Window For Results;" You have to make the directive to the command window.

Then, two instructions appear before you. The first is the result without taking into account Ionosphere, Troposphere and Total Groud Delay, and the second is a result that includes these delays. For this, a loop was created as recommended by our teacher Metin and an output was obtained in both results. Also, the Ground Truth in the project directive was calculated.

For the Final Project, the part seen in Figure 2 was calculated in previous assignments. The reason I included this again in my final project is because more than one satellite was not included in the process before, but I included 10 satellites in the new epoch that I calculated in this project.

```
row_len = size(SP3, 1);
% Lists for Append
satellites_position = [];
state_list = [];

for i=1:row_len
    dt = C1(i,:)/c; % dt is t_reception - t_emission - pc = P
    sat_t_emist = trec - dt; % time of signal transmission (satellite clock) trec = treception

    clk =SP3(:,:,i); % satellite clock errors in SP3 matrices
    clk(:,5) =clk(:,5)*10^-6; % 10^-6 convertion for satellite clock correction

    % δt_sat - (Reception time and satellite clock corrections)
    sat_clock_correction = lagrange(sat_t_emist,clk(:, [1, 5]));
    % Satellite coordinates in ECEF at Reception Time
    [fpos] =sat_pos(trec, C1(i,:), SP3(:,:,i), rec);
    satellites_position(i,:)= fpos; % For All Satellites
    % last homework parameters for delays (atmos)
    [az, zen, slantd, IonD, TrD, TrW] = atmos(doy, trec, trecw, C1(i,:), rec, SP3(:,:,i),alpha,beta);
```

*Figure 2*

Therefore, without recounting these parts, I would like to move on to the important part of our homework.

```
%initial receiver coordinates as zero
X = 0;
Y = 0;
Z = 0;
while true % starting Least Squares Method.
    % Geometric range linearization, reference slides10
    pj_0 = sqrt((sats_coor_list(:, 1) - X).^2+(sats_coor_list(:, 2) - Y).^2+((sats_coor_list(:, 3) - Z).^2));
    % reduced obserbation vector, reference slides10
    l = C1 -pj_0-state_list ;
    % design matrix, reference slides10
    A=[(X -sats_coor_list(:, 1))./pj_0,(Y -sats_coor_list(:, 2))./pj_0,(Z -sats_coor_list(:, 3))./pj_0 ,ones(row_len,1)];
    % vector of unknown parameters, reference slides10
    transpose_X= A\l;
    % Vector of unkown parameters, corrections to approx receiver coor
    dx = transpose_X(1,1);
    dy = transpose_X(2,1);
    dz = transpose_X(3,1);
    % correction time, reference slides10
    T_delta = transpose_X(4,1)/c;
    %(X=0, Y=0, Z=0) and break the iterations when the
    %differences in each component (dX, dY, dZ) is less than 1-mm.
    if abs(dx) < (10^-3) && abs(dy) < (10^-3) && abs(dz) < (10^-3)
        break
    else
        % Current station coordinates
        X = X +dx;
        Y = Y +dy;
        Z = Z +dz;
    end
end
% STATION COORDINATES IN ECEF
```

*Figure 3*

As seen in Figure 3, I wrote a while loop using the Least Square Method in the new part of my code.

Here, I first calculated the Geometric range linearization. Next, I created a reduced obserbation vector and design matrix. I transposed the vectors I created and added the corrected Delta values to my Mers Station coordinator.

**In my output analysis, I saw that the ground_truth value was less when I included the delays, so my coordinates I obtained were more precise.**

## Outputs ;

```
>> last_project(C1,SP3,doy,trec,trecw,rec,alpha,beta,TGD)
 1 is excluding delays and 2 is including delays:  1
STATION COORDINATES IN ECEF

ground_truth =

          30.2256522552747


ans =

          4239173.29966682
          2886976.73971199
          3778893.24457009

>> last_project(C1,SP3,doy,trec,trecw,rec,alpha,beta,TGD)
 1 is excluding delays and 2 is including delays:  2
STATION COORDINATES IN ECEF

ground_truth =

          5.69506545323226


ans =

          4239151.85859527
           2886969.5357325
          3778882.01502936

>>
```