The Hong Kong Polytechnic University

The Department of Land Surveying and Geo-informatics

2021 - 2022 Semester 1

LSGI3322: Satellite Positioning Systems

Subject Lecturer: Prof. George Liu & Prof. Wu Chen

Final Individual Project: GPS Positioning (30%)

Intermediate Report 1: Reading Two GPS RINEX Files (7%)

Due Date: 06-10-2021 23:59

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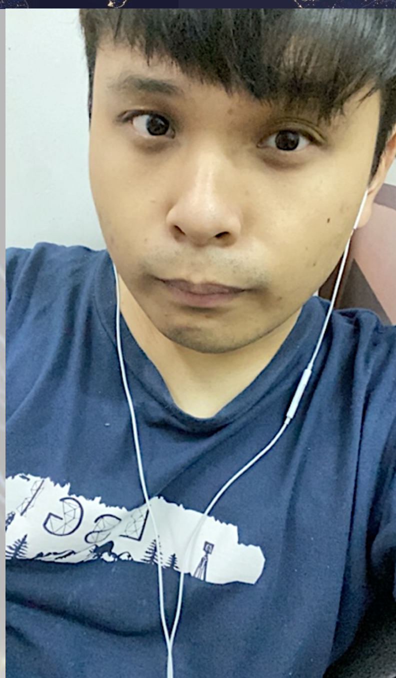
Expected Grade: A Range



1 Objective

To complete the final project which counts for 30% scores of LSGI3322, it is then divided into three sections:

- 7 % - Reading Two GPS RINEX data files (6/10)
- 8 % - Computing GPS Satellite Positioning (3/11)
- 15% - Final Production: Single Point Positioning using Pseudo-range Measurement (12/12)

In the **First Intermediate Report**, the mission is to read two GPS RINEX data files, in terms of navigation and observation files (the given data: site0900.01n and site0900.01o) by using self-developed programs is conduced. I have chosen MATLAB program software to complete this individual project.

2 RINEX Data Structure

2.1 RINEX Navigation File

The below displays the navigation file "site0900.01n" in RINEX format. It is used the first section as an example

site0900(1).01n

```
     2              NAVIGATION DATA                         RINEX VERSION / TYPE
CCRINEXN V1.5.9 UX  CDDIS               02-APR-00 07:08     PGM / RUN BY / DATE
IGS BROADCAST EPHEMERIS FILE                                COMMENT
    0.4191D-07  0.1490D-07 -0.2384D-06 -0.5961D-07          ION ALPHA
    0.1495D+06  0.0000D+00 -0.3932D+06  0.3932D+06          ION BETA
   -0.239808173319D-13-0.139698386192D-07    61440     1108 DELTA-UTC: A0,A1,T,W
    13                                                      LEAP SECONDS
                                                            END OF HEADER
 2 01  3 31  0  0  0.0-0.360158272088D-03-0.534328137292D-11 0.000000000000D+00
    0.520000000000D+02 0.781250000000D+01 0.497556439509D-08 0.187238074216D+01
    0.162050127983D-06 0.207882055547D-01 0.959262251854D-05 0.515368904686D+04
    0.518400000000D+06-0.221654772758D-06 0.551731029172D+00-0.441446900368D-06
    0.933503344596D+00 0.181281250000D+03-0.205664455792D+01-0.816105422638D-08
   -0.263225250103D-09 0.000000000000D+00 0.110700000000D+04 0.000000000000D+00
    0.100000000000D+01 0.000000000000D+00-0.186264514923D-08 0.564000000000D+03
    0.511530000000D+06 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
 3 01  3 31  0  0  0.0 0.162767246366D-04 0.318323145621D-11 0.000000000000D+00
    0.530000000000D+02 0.863125000000D+02 0.498020744563D-08 0.349439502758D+00
    0.443309545517D-05 0.209663005080D-02 0.779703259468D-05 0.515368713570D+04
    0.518400000000D+06 0.000000000000D+00 0.163186669490D+01 0.596046447754D-07
    0.937299053788D+00 0.218531250000D+03 0.714973987799D+00-0.833034699239D-08
    0.957182727646D-10 0.100000000000D+01 0.110700000000D+04 0.000000000000D+00
    0.400000000000D+01 0.000000000000D+00-0.465661287308D-08 0.565000000000D+03
    0.518148000000D+06 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
 4 01  3 31  0  0  0.0 0.700922217220D-03 0.250111042988D-11 0.000000000000D+00
```

Example

Table 1. An Interpretation of GPS RINEX Navigation File.

Explanation of GPS Navigation Data Record									
2	01	3	31	0	0	0	-0.36158272088D-3	-0.534328137292D-11	0.00000000000D+00
Recorder identifier	Year (2-digit)	Month	Day	Hour	Minute	Second (2 digits)	SV clock bias (seconds)	SV clock drift (sec/sec)	SV clock drift rate (sec/sec2)
0.520000000000D+02			0.781250000000D+01			0.497556439509D-08		0.187238074216D+01	
Ephemeris			Crs (meters)			Delta n (radian/sec)		M0 (radians)	
0.162050127983D-06			0.207882055547D-01			0.959262251854D-05		0.515368904686D+04	
Cuc (radians)			e Eccentricity			Cus (radians)		sqrt(A) (sqrt(m))	
0.518400000000D+06			-0.221654772758D-06			0.551731029172D+00		-0.441446900368D-08	
Toe Time of Ephemeris (Sec of BDT week)			Cic (radians)			OMEGA0 (radians)		Cis (radians)	
0.933503344596D+00			0.181281250000D+03			-0.205664455792D+01		-0.816105422638D-08	
i0			Crc (meters)			omega (radians)		OMEGA DOT (radians/sec)	
-0.263225250103D-09			0.000000000000D+00			0.1107000000000D+04		0.000000000000D+00	
IDOT (radians/sec)			Codes on L2 channel			GPS week		L2 P Data Flag	
0.100000000000D+01			0.000000000000D+00			-0.1862624514923D-08		0.564000000000D+03	
SV Accuracy (meters)			SV Health			TGD (seconds)		IODC Issue of Date, Clock	
0.511530000000D+06			0.000000000000D+00						
Transmission Time of Message			Fit interval (hours)			Spare		Spare	

2.1 RINEX Observation File

The below shows the observation data file "site0900.01o" in RINEX format.

site0900(1).01o

```
 1      2.10           OBSERVATION DATA    G (GPS)            RINEX VERSION / TYPE
 2 teqc  2000Jul20     WCDA Data collecting20010401 00:12:37UTCPGM / RUN BY / DATE
 3 Solaris 2.7|Ultra 2|cc SC5.0|=+-|*Sparc                    COMMENT
 4 teqc  2000Jul20     WCDA Data collecting20010401 00:12:31UTCCOMMENT
 5 teqc  2000Jul20     WCDA Data collecting20010331 01:12:17UTCCOMMENT
 6 site                                  xxxxxx               MARKER NAME
 7 xxxxxxxxx                                                  MARKER NUMBER
 8 xxxxxxxx            xxxxxxxxxxxxxxxxxx                     OBSERVER / AGENCY
 9 2025                AOA BENCHMARK ACT    3.3.32.2N 1k99/07/28REC # / TYPE / VERS
10 95174               AOAD/M_T        EMRA                   ANT # / TYPE
11  00000001.0000 00000001.0000  0000001.0000                 APPROX POSITION XYZ
12        0.1000        0.0000        0.0000                  ANTENNA: DELTA H/E/N
13      1     1                                               WAVELENGTH FACT L1/2
14      7    L1    L2    C1    P1    P2    S1    S2           # / TYPES OF OBSERV
15     30.0000                                                INTERVAL
16 STATION INFORMATION EFFECTIVE FROM: 2000/03/15 18:18:00    COMMENT
17                                 TO: CURRENT DATE (above)   COMMENT
18 BIT 2 OF LLI FLAGS (+4) DATA COLLECTED UNDER 'AS' CONDITIONCOMMENT
19 L1 PHASE CENTRE 0.110m ABOVE ARP                           COMMENT
20 L2 PHASE CENTRE 0.128m ABOVE ARP                           COMMENT
21 where ARP is the Antenna Reference Point for HI measurementCOMMENT
22 CONTACT xxxxx@pgc.nrcan.gc.ca FOR ADDITIONAL INFORMATION   COMMENT
23     P1 =     P1  TurboRogue; =    Y1  Benchmark            COMMENT
24     L1 = L1(CA)                                            COMMENT
25     P2 =     P2  TurboRogue; =    Y2  Benchmark            COMMENT
26     L2 = L2(P2) TurboRogue; = L2(Y2) Benchmark             COMMENT
27  SNR is mapped to RINEX snr flag value [1,4-9]             COMMENT
28     SNR:   >316  >100  >31.6  >10  >3.2    >0 bad=0        COMMENT
29 L1 & L2:      9     8     7     6     5     4     1        COMMENT
30   2001     3    31     0     0   0.0000000     GPS         TIME OF FIRST OBS
31                                                            END OF HEADER
32  01  3 31  0  0  0.0000000  0 10G10G22G17G15G18G 6G26G28G23G 3
33   -4571014.571 4  -3561795.634 4  23688534.679    23688535.001    23688542.297
34        37.000           27.000
35   -8749437.103 5  -6817728.119 5  22540847.552    22540847.117    22540852.845
36        66.000           48.000
```

Interpretation

Table 2. An Interpretation of GPS RINEX Observation File.

Explanation of GPS Observation Data Record			
Line 1	RINEX VERSION / TYPE	2.10	Format version
		OBSERVATION DATA	File type: O for Observation Data
		G (GPS)	Satellite System
Line 2,4,5	PGM / RUN BY / DATE	teqc	Name of program creating current file
		WCDA Data	Name of agency creating current file
		2000 July 20	Date and time of file creation
Line 3	COMMENT	Solaris 2.7 | Ultra 2 | cc SC5.0 | =+-| *Sparc	Solaris System
Line 6	MARKER NAME	site xxxxxx	The name of the marker
Line 7	MARKER NUMBER	xxxxxxxxx	The number of the marker
Line 8	OBSERVER / AGENCY	xxxxxxxxx xxxxxxxxxxxxxxxxx	The name of the observer or agency
Line 9	REC # / TYPE/ VERS	2025	Receiver number
		AOA BENCHMARK ACT	Type
		3.3.32.2N 1k99/07/28REC	Version
Line 10	ANT # / TYPE	SG6085133254175	Antenna number
		STHG6SG6X-T970A	Type
Line 11	APPROX POSITION XYZ	X: 00000001.0000 Y: 00000001.0000 Z: 00000001.0000	Geocentric approximate marker position
Line 12	ANTENNA: DELTA H/E/N	0.100	- Antenna height: Height of the antenna reference point (ARP) above the marker
		East: 0.0000 West: 0.0000	- Horizontal eccentricity of ARP relative to the marker (east/north)
Line 13	WAVELENGTH FACT L1/ L2	1 1	The wavelength of LI and L2
Line 14	#/ TYPES OF OBSER	-Satellite system code: G R E C S -Number of different observation types for the specified satellite system: 9 11 9 5 5 -Observation descriptors:	- Satellite system code (G/R/E/J/C/I/S) - Number of different observation types for the specified satellite system - Observation descriptors: Type: C = Code / Pseudorange L = Phase D = Doppler Band: 1= L1 2= L2 5= L5 7= E5b 8= E5a+b

		C1C L1C D1C C2W L2W C2X L2X C5X L5X C1C L1C D1C C1P L1P C2C L2C C2P L2P C3X C1X L1X D1X C8X L8X C7X L7X C5X L5X C1I L1I D1I C7I L7I C1C L1C D1C C5I L5I	Attribute: P: P code-based C: C code-based X: I+Q channels W: based on Z-tracking I: I channel
Line 15	INTERVAL	5.000	Observation interval in seconds
Line 16-17	STATION INFORMATION EFFECTIVE DAY	2000/03/15 18:18:00	The effective day of the station information
Line 18	COMMENT	BIT 2 OF LLI FLAGS (+4) DATA COLLECTED UNDER 'AS' CONDITION	The information of Loss-of-lock indicator
Line 19	L1 PHASE CENTRE	0.110 M ABOVE ARP	The information of L1 phase centre
Line 20	L2 PHASE CENTER	0.118 M ABOVE ARP	The information of L2 phase centre
Line 21-29	COMMENT	/	The Information of Sound Noise Ratio (SNR)
Line 30	TIME OF FIRST OBS	Year:2001 Month: 03 Day: 31 Hour: 0 Min: 0 Sec: 0.00000000 Time System: GPS	Time of first observation record (4-digit-year, month, day, hour, min, sec)
Line 31	END OF HEADER	/	Last record in the header section

3 Programming Script

In this section, MATLAB program is used to first read navigation and observation files. Afterwards, MATLAB program is also used for the upcoming orbit computation as well as the pseudo-range measurement.

3.1 Reading RINEX Navigation File

MATLAB programme script for reading the RINEX navigation file. The result is shown in Section 4.1. To get a better readability, the general steps are also commented.

```
%=========================================================================
%======================Read RINEX Navigation File=========================
%=========================================================================
navigation_path='site0900.01n';
Nav_Data=fopen(navigation_path,'r');
%==========Find out the header section "END OF HEADER"=====================
Read_Nav_Line=fgetl(Nav_Data);
while ischar(Read_Nav_Line)
if contains(Read_Nav_Line, 'END OF HEADER');
break;
end

Read_Nav_Line=fgetl(Nav_Data);
end
%======================Read Navigation Data================================
Epoch_Nav=1;
while ischar(Read_Nav_Line)
Read_Nav_Line=fgetl(Nav_Data);
if (Read_Nav_Line == -1)
Epoch_Nav=Epoch_Nav-1;
break;
end
%=========================CV/ Epoch/ SV CLK================================
nav(Epoch_Nav).PRN=str2num(Read_Nav_Line(1:2));
nav(Epoch_Nav).Year=str2num(Read_Nav_Line(4:5));
nav(Epoch_Nav).Month=str2num(Read_Nav_Line(7:8));
nav(Epoch_Nav).Day=str2num(Read_Nav_Line(10:11));
nav(Epoch_Nav).Hour=str2num(Read_Nav_Line(13:14));
nav(Epoch_Nav).Minute=str2num(Read_Nav_Line(16:17));
nav(Epoch_Nav).Second=str2num(Read_Nav_Line(18:22));
nav(Epoch_Nav).Date_Numerical=datenum(nav(Epoch_Nav).Year,nav(Epoch_Nav).Month,nav(Epoch_Nav).Day,
nav(Epoch_Nav).Hour,nav(Epoch_Nav).Minute,nav(Epoch_Nav).Second);
No_of_weekday_In_nav=weekday(nav(Epoch_Nav).Date_Numerical)-1;
nav(Epoch_Nav).Time_in_GPS=No_of_weekday_In_nav*60*60*24+nav(Epoch_Nav).Hour*60*60+nav(Epoch_Nav).
Minute*60+nav(Epoch_Nav).Second;
nav(Epoch_Nav).SV_Clock_Bias=str2num(Read_Nav_Line(23:41));
```

```
nav(Epoch_Nav).SV_Clock_drift=str2num(Read_Nav_Line(42:60));
nav(Epoch_Nav).SV_Clock_drift_rate=str2num(Read_Nav_Line(61:79));
Read_Nav_Line=fgetl(Nav_Data);
%==========================Broadcast Orbit - 1=============================
nav(Epoch_Nav).IODE=str2num(Read_Nav_Line(4:22));
nav(Epoch_Nav).Crs=str2num(Read_Nav_Line(23:41));
nav(Epoch_Nav).Delta_N=str2num(Read_Nav_Line(42:60));
nav(Epoch_Nav).M0=str2num(Read_Nav_Line(61:79));
Read_Nav_Line=fgetl(Nav_Data);
%==========================Broadcast Orbit - 2=============================
nav(Epoch_Nav).Cuc=str2num(Read_Nav_Line(4:22));
nav(Epoch_Nav).e=str2num(Read_Nav_Line(23:41));
nav(Epoch_Nav).Cus=str2num(Read_Nav_Line(42:60));
nav(Epoch_Nav).sqrt_a=str2num(Read_Nav_Line(61:79));
Read_Nav_Line=fgetl(Nav_Data);
%==========================Broadcast Orbit - 3=============================
nav(Epoch_Nav).Toe_time=str2num(Read_Nav_Line(4:22));
nav(Epoch_Nav).Cic=str2num(Read_Nav_Line(23:41));
nav(Epoch_Nav).Omega_0=str2num(Read_Nav_Line(42:60));
nav(Epoch_Nav).CIS=str2num(Read_Nav_Line(61:79));
Read_Nav_Line=fgetl(Nav_Data);
%==========================Broadcast Orbit - 4=============================
nav(Epoch_Nav).i0=str2num(Read_Nav_Line(4:22));
nav(Epoch_Nav).Crc=str2num(Read_Nav_Line(23:41));
nav(Epoch_Nav).Omega=str2num(Read_Nav_Line(42:60));
nav(Epoch_Nav).Omega_dot=str2num(Read_Nav_Line(61:79));
Read_Nav_Line=fgetl(Nav_Data);
%==========================Broadcast Orbit - 5=============================
nav(Epoch_Nav).IDOT=str2num(Read_Nav_Line(4:22));
nav(Epoch_Nav).weekNO=str2num(Read_Nav_Line(42:60));
Read_Nav_Line=fgetl(Nav_Data);
%==========================Broadcast Orbit - 6=============================
nav(Epoch_Nav).SV_accuracy=str2num(Read_Nav_Line(4:22));
nav(Epoch_Nav).SV_health=str2num(Read_Nav_Line(23:41));
nav(Epoch_Nav).TGD=str2num(Read_Nav_Line(42:60));
nav(Epoch_Nav).IODC=str2num(Read_Nav_Line(61:79));
Read_Nav_Line=fgetl(Nav_Data);
%==========================Broadcast Orbit - 7=============================
nav(Epoch_Nav).Transmission_timeofMessage=str2num(Read_Nav_Line(4:22));
nav(Epoch_Nav).Fit_interval=str2num(Read_Nav_Line(23:41));
nav(Epoch_Nav).Spare_1=str2num(Read_Nav_Line(42:60));
nav(Epoch_Nav).Spare_2=str2num(Read_Nav_Line(61:79));

Epoch_Nav=Epoch_Nav+1;
%==================The END of Reading Navigation Data======================
end
```

3.2 Reading RINEX Observation File

MATLAB programme script for reading the RINEX observation file. The result is shown in Section 4.2. To get a better understanding, the general steps are also commented.

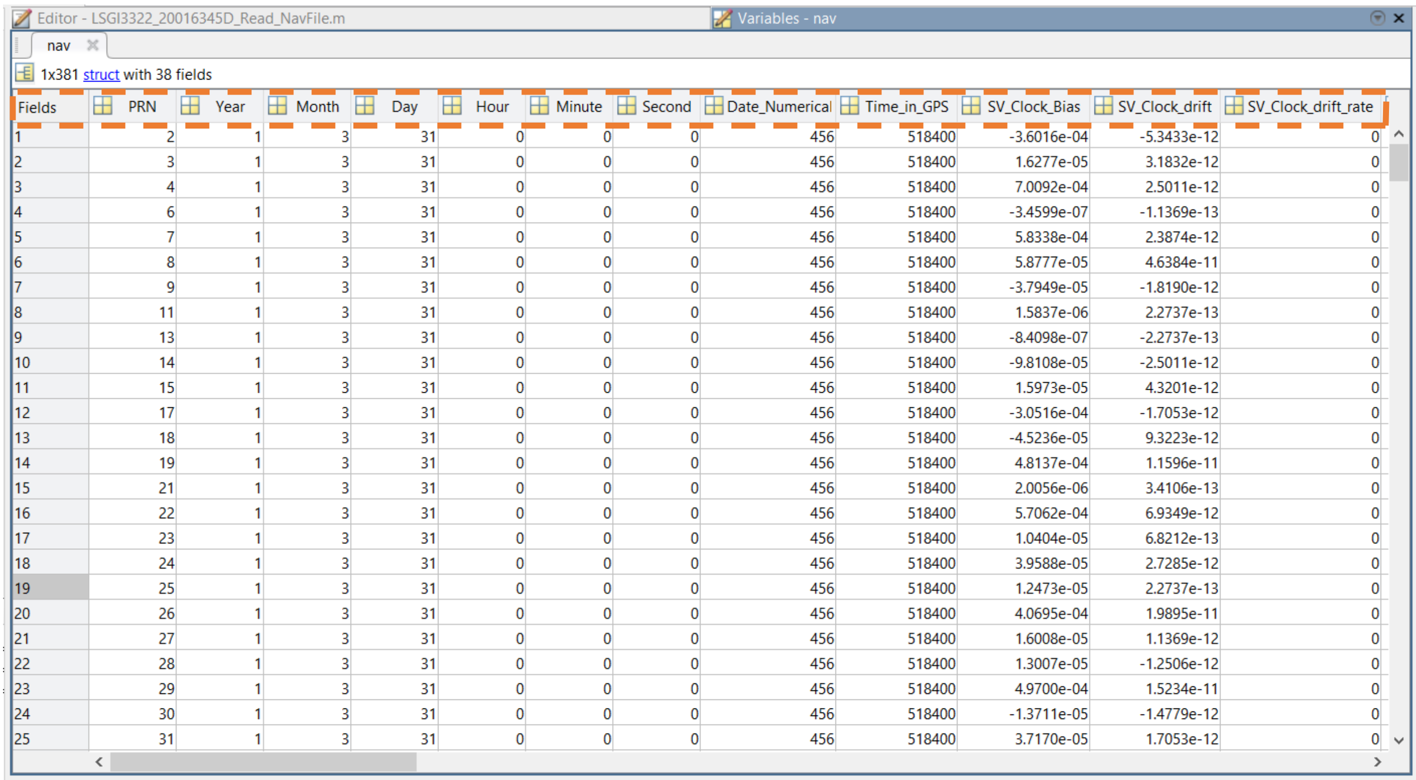
```
%==========================================================================
%======================Read RINEX Observation File=========================
%==========================================================================
Observation_path='site0900.01o';
ObsData=fopen(Observation_path,'r');

%======================Find the number of Satellites=======================
Read_Obs_C_Line=fgetl(ObsData);
while ischar(Read_Obs_C_Line)
if contains(Read_Obs_C_Line, '# / TYPES OF OBSERV');
break;
end

Read_Obs_C_Line=fgetl(ObsData);
end
```

```
No_of_Satellite=str2num(Read_Obs_C_Line(4:6));
%===============Find the C Position Index of Satellites====================
for i=1:No_of_Satellite
Types_of_observation{i}=Read_Obs_C_Line(4+6*i:6+6*i);
end

C_position_index = find(contains(Types_of_observation,'C1'));

%===============Find the Wording: "TIME OF FIRST OBS"======================
Read_ObsLine=fgetl(ObsData);
while ischar(Read_ObsLine)
if contains(Read_ObsLine, 'TIME OF FIRST OBS');
Obs_Time_of_first_obs=string(Read_ObsLine(5:6));
break;
end

Read_ObsLine=fgetl(ObsData);
end
%===============Find the Wording: "END OF HEADER"==========================
Read_ObsLine=fgetl(ObsData);
while ischar(Read_ObsLine)
if contains(Read_ObsLine, 'END OF HEADER');
break;
end

Read_ObsLine=fgetl(ObsData);
end
%=======================Read Navigation Data===============================
Epoth_Obs=0;
while ischar(Read_ObsLine)
Read_ObsLine=fgetl(ObsData);
if (Read_ObsLine == -1)
Epoth_Obs=Epoth_Obs-1;
break;
end

if isequal(string(Read_ObsLine(2:3)),Obs_Time_of_first_obs)
   No_of_PRN=str2num(Read_ObsLine(31:32));

for j=1: No_of_PRN
Obs(Epoth_Obs + j).PRN=str2num(Read_ObsLine(31+3*j:32+3*j));
Obs(Epoth_Obs + j).Year=str2num(Read_ObsLine(1:3))+2000;
Obs(Epoth_Obs + j).Month=str2num(Read_ObsLine(5:6));
Obs(Epoth_Obs + j).Day=str2num(Read_ObsLine(7:9));
Obs(Epoth_Obs + j).Hour=str2num(Read_ObsLine(11:12));
Obs(Epoth_Obs + j).Minute=str2num(Read_ObsLine(14:15));
Obs(Epoth_Obs + j).Second=str2num(Read_ObsLine(17:26));
Obs(Epoth_Obs + j).Epoch_Flag=str2num(Read_ObsLine(28:29));
Obs(Epoth_Obs + j).Date_numerical=datenum(Obs(Epoth_Obs + j).Year,Obs(Epoth_Obs +
j).Month,Obs(Epoth_Obs + j).Day,Obs(Epoth_Obs + j).Hour,Obs(Epoth_Obs + j).Minute,Obs(Epoth_Obs +
j).Second);
No_of_weekday_In_Obs=weekday(Obs(Epoth_Obs + j).Date_numerical)-1;
Obs(Epoth_Obs + j).Time_in_GPS=No_of_weekday_In_Obs*60*60*24+Obs(Epoth_Obs +
j).Hour*60*60+Obs(Epoth_Obs + j).Minute*60+Obs(Epoth_Obs + j).Second;
end
%====================Read C1 Epoch’s GPS Data==============================
for k=1:No_of_PRN
Read_ObsLine=fgetl(ObsData);
Obs(Epoth_Obs + k).C1 = str2num(Read_ObsLine(2+16*C_position_index:14+16*C_position_index));
Read_ObsLine=fgetl(ObsData);
end

Epoth_Obs=Epoth_Obs + No_of_PRN;
end
%==================The END of Reading Observation Data=====================
end
```

4 Output

4.1 Navigation File

The below screenshots shows the output of the above-mentioned MATLAB navigation scripts. The output is a 1x381 data structure, which contains: *PRN, year, month, day, hour, minute, second, date, GPS time, SV clock bias, SV clock drift and rate, IODE, Crs, delta n, m0, Cuc, e , Cus, sqrt (a), toe time, Cie, omega_0, Cis, i0, Crc, omega, omega dot, IDOT, week number, SV accuracy and SV health, TGD, IODC, Transmission of time mess, fit interval and spares.*



Editor - LSGI3322_20016345D_Read_NavFile.m

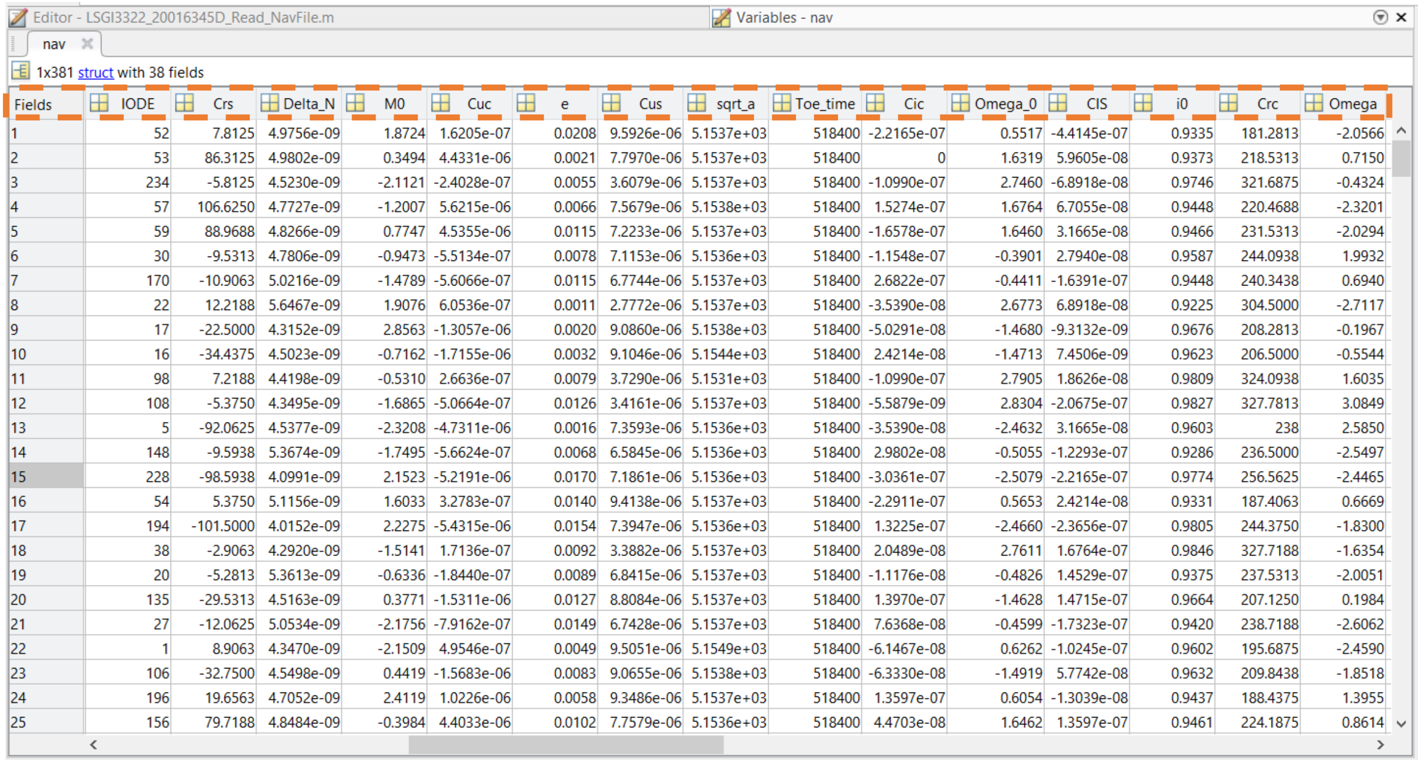
Variables - nav

nav

1x381 struct with 38 fields

Fields	PRN	Year	Month	Day	Hour	Minute	Second	Date_Numerical	Time_in_GPS	SV_Clock_Bias	SV_Clock_drift	SV_Clock_drift_rate
1	2	1	3	31	0	0	0	456	518400	-3.6016e-04	-5.3433e-12	0
2	3	1	3	31	0	0	0	456	518400	1.6277e-05	3.1832e-12	0
3	4	1	3	31	0	0	0	456	518400	7.0092e-04	2.5011e-12	0
4	6	1	3	31	0	0	0	456	518400	-3.4599e-07	-1.1369e-13	0
5	7	1	3	31	0	0	0	456	518400	5.8338e-04	2.3874e-12	0
6	8	1	3	31	0	0	0	456	518400	5.8777e-05	4.6384e-11	0
7	9	1	3	31	0	0	0	456	518400	-3.7949e-05	-1.8190e-12	0
8	11	1	3	31	0	0	0	456	518400	1.5837e-06	2.2737e-13	0
9	13	1	3	31	0	0	0	456	518400	-8.4098e-07	-2.2737e-13	0
10	14	1	3	31	0	0	0	456	518400	-9.8108e-05	-2.5011e-12	0
11	15	1	3	31	0	0	0	456	518400	1.5973e-05	4.3201e-12	0
12	17	1	3	31	0	0	0	456	518400	-3.0516e-04	-1.7053e-12	0
13	18	1	3	31	0	0	0	456	518400	-4.5236e-05	9.3223e-12	0
14	19	1	3	31	0	0	0	456	518400	4.8137e-04	1.1596e-11	0
15	21	1	3	31	0	0	0	456	518400	2.0056e-06	3.4106e-13	0
16	22	1	3	31	0	0	0	456	518400	5.7062e-04	6.9349e-12	0
17	23	1	3	31	0	0	0	456	518400	1.0404e-05	6.8212e-13	0
18	24	1	3	31	0	0	0	456	518400	3.9588e-05	2.7285e-12	0
19	25	1	3	31	0	0	0	456	518400	1.2473e-05	2.2737e-13	0
20	26	1	3	31	0	0	0	456	518400	4.0695e-04	1.9895e-11	0
21	27	1	3	31	0	0	0	456	518400	1.6008e-05	1.1369e-12	0
22	28	1	3	31	0	0	0	456	518400	1.3007e-05	-1.2506e-12	0
23	29	1	3	31	0	0	0	456	518400	4.9700e-04	1.5234e-11	0
24	30	1	3	31	0	0	0	456	518400	-1.3711e-05	-1.4779e-12	0
25	31	1	3	31	0	0	0	456	518400	3.7170e-05	1.7053e-12	0

Figure 1. Screenshot 1 of Reading RINEX Navigation Data



Editor - LSGI3322_20016345D_Read_NavFile.m

Variables - nav

nav

1x381 struct with 38 fields

Fields	IODE	Crs	Delta_N	M0	Cuc	e	Cus	sqrt_a	Toe_time	Cic	Omega_0	CIS	i0	Crc	Omega
1	52	7.8125	4.9756e-09	1.8724	1.6205e-07	0.0208	9.5926e-06	5.1537e+03	518400	-2.2165e-07	0.5517	-4.4145e-07	0.9335	181.2813	-2.0566
2	53	86.3125	4.9802e-09	0.3494	4.4331e-06	0.0021	7.7970e-06	5.1537e+03	518400	0	1.6319	5.9605e-08	0.9373	218.5313	0.7150
3	234	-5.8125	4.5230e-09	-2.1121	-2.4028e-07	0.0055	3.6079e-06	5.1537e+03	518400	-1.0990e-07	2.7460	-6.8918e-08	0.9746	321.6875	-0.4324
4	57	106.6250	4.7727e-09	-1.2007	5.6215e-06	0.0066	7.5679e-06	5.1538e+03	518400	1.5274e-07	1.6764	6.7055e-08	0.9448	220.4688	-2.3201
5	59	88.9688	4.8266e-09	0.7747	4.5355e-06	0.0115	7.2233e-06	5.1537e+03	518400	-1.6578e-07	1.6460	3.1665e-08	0.9466	231.5313	-2.0294
6	30	-9.5313	4.7806e-09	-0.9473	-5.5134e-07	0.0078	7.1153e-06	5.1536e+03	518400	-1.1548e-07	-0.3901	2.7940e-08	0.9587	244.0938	1.9932
7	170	-10.9063	5.0216e-09	-1.4789	-5.6066e-07	0.0115	6.7744e-06	5.1537e+03	518400	2.6822e-07	-0.4411	-1.6391e-07	0.9448	240.3438	0.6940
8	22	12.2188	5.6467e-09	1.9076	6.0536e-07	0.0011	2.7772e-06	5.1537e+03	518400	-3.5390e-08	2.6773	6.8918e-08	0.9225	304.5000	-2.7117
9	17	-22.5000	4.3152e-09	2.8563	-1.3057e-06	0.0020	9.0860e-06	5.1538e+03	518400	-5.0291e-08	-1.4680	-9.3132e-09	0.9676	208.2813	-0.1967
10	16	-34.4375	4.5023e-09	-0.7162	-1.7155e-06	0.0032	9.1046e-06	5.1544e+03	518400	2.4214e-08	-1.4713	7.4506e-09	0.9623	206.5000	-0.5544
11	98	7.2188	4.4198e-09	-0.5310	2.6636e-07	0.0079	3.7290e-06	5.1531e+03	518400	-1.0990e-07	2.7905	1.8626e-08	0.9809	324.0938	1.6035
12	108	-5.3750	4.3495e-09	-1.6865	-5.0664e-07	0.0126	3.4161e-06	5.1537e+03	518400	-5.5879e-09	2.8304	-2.0675e-07	0.9827	327.7813	3.0849
13	5	-92.0625	4.5377e-09	-2.3208	-4.7311e-06	0.0016	7.3593e-06	5.1536e+03	518400	-3.5390e-08	-2.4632	3.1665e-08	0.9603	238	2.5850
14	148	-9.5938	5.3674e-09	-1.7495	-5.6624e-07	0.0068	6.5845e-06	5.1536e+03	518400	2.9802e-08	-0.5055	-1.2293e-07	0.9286	236.5000	-2.5497
15	228	-98.5938	4.0991e-09	2.1523	-5.2191e-06	0.0170	7.1861e-06	5.1536e+03	518400	-3.0361e-07	-2.5079	-2.2165e-07	0.9774	256.5625	-2.4465
16	54	5.3750	5.1156e-09	1.6033	3.2783e-07	0.0140	9.4138e-06	5.1537e+03	518400	-2.2911e-07	0.5653	2.4214e-08	0.9331	187.4063	0.6669
17	194	-101.5000	4.0152e-09	2.2275	-5.4315e-06	0.0154	7.3947e-06	5.1536e+03	518400	1.3225e-07	-2.4660	-2.3656e-07	0.9805	244.3750	-1.8300
18	38	-2.9063	4.2920e-09	-1.5141	1.7136e-07	0.0092	3.3882e-06	5.1537e+03	518400	2.0489e-08	2.7611	1.6764e-07	0.9846	327.7188	-1.6354
19	20	-5.2813	5.3613e-09	-0.6336	-1.8440e-07	0.0089	6.8415e-06	5.1537e+03	518400	-1.1176e-08	-0.4826	1.4529e-07	0.9375	237.5313	-2.0051
20	135	-29.5313	4.5163e-09	0.3771	-1.5311e-06	0.0127	8.8084e-06	5.1537e+03	518400	1.3970e-07	-1.4628	1.4715e-07	0.9664	207.1250	0.1984
21	27	-12.0625	5.0534e-09	-2.1756	-7.9162e-07	0.0149	6.7428e-06	5.1537e+03	518400	7.6368e-08	-0.4599	-1.7323e-07	0.9420	238.7188	-2.6062
22	1	8.9063	4.3470e-09	-2.1509	4.9546e-07	0.0049	9.5051e-06	5.1549e+03	518400	-6.1467e-08	0.6262	-1.0245e-07	0.9602	195.6875	-2.4590
23	106	-32.7500	4.5498e-09	0.4419	-1.5683e-06	0.0083	9.0655e-06	5.1538e+03	518400	-6.3330e-08	-1.4919	5.7742e-08	0.9632	209.8438	-1.8518
24	196	19.6563	4.7052e-09	2.4119	1.0226e-06	0.0058	9.3486e-06	5.1537e+03	518400	1.3597e-07	0.6054	-1.3039e-08	0.9437	188.4375	1.3955
25	156	79.7188	4.8484e-09	-0.3984	4.4033e-06	0.0102	7.7579e-06	5.1536e+03	518400	4.4703e-08	1.6462	1.3597e-07	0.9461	224.1875	0.8614

Figure 2. Screenshot 2 of Reading RINEX Navigation Data

Editor - LSGI3322_20016345D_Read_NavFile.m | Variables - nav

nav

1x381 struct with 38 fields

Fields	Omega_dot	IDOT	weekNO	SV_accuracy	SV_health	TGD	IODC	Transmission_timeofMess	Fit_interval	Spare_1	Spare_2
1	-8.1611e-09	-2.6323e-10	1107	1	0	-1.8626e-09	564	511530	0	0	0
2	-8.3303e-09	9.5718e-11	1107	4	0	-4.6566e-09	565	518148	0	0	0
3	-8.2207e-09	2.2858e-11	1107	2	0	-6.0536e-09	234	511218	0	0	0
4	-8.2671e-09	1.5536e-10	1107	2.8000	0	-5.1223e-09	569	511218	0	0	0
5	-8.4407e-09	2.0358e-11	1107	0	0	-2.3283e-09	59	511410	0	0	0
6	-8.2264e-09	-1.3572e-11	1107	2	0	-4.6566e-09	30	515538	0	0	0
7	-8.1336e-09	-4.3930e-11	1107	0	0	-6.0536e-09	170	511350	0	0	0
8	-8.8243e-09	6.6074e-11	1107	1	0	-8.3819e-09	790	512100	0	0	0
9	-7.8625e-09	2.0715e-10	1107	2	0	-1.1642e-08	529	511218	0	0	0
10	-7.9896e-09	2.7715e-10	1107	2	0	-1.0245e-08	272	511740	0	0	0
11	-8.3743e-09	7.6075e-11	1107	4	60	-2.7940e-09	98	511218	0	0	0
12	-8.2346e-09	1.7286e-10	1107	2.8000	0	-2.3283e-09	364	511218	0	0	0
13	-8.1228e-09	-9.9647e-11	1107	4	0	-7.4506e-09	261	514278	0	0	0
14	-8.3618e-09	3.0358e-11	1107	6.8500	60	-3.2596e-09	404	511206	0	0	0
15	-7.8600e-09	-7.9289e-11	1107	1	0	-1.8626e-09	228	511800	0	0	0
16	-8.3671e-09	-4.4859e-10	1107	2.8000	0	-4.1910e-09	310	511878	0	0	0
17	-7.6878e-09	-1.3929e-10	1107	2.8000	0	-2.7940e-09	450	513078	0	0	0
18	-8.1282e-09	2.9287e-11	1107	4	0	-9.3132e-10	550	511218	0	0	0
19	-8.5436e-09	1.7858e-11	1107	4	0	-7.4506e-09	276	511218	0	0	0
20	-8.1221e-09	1.9465e-10	1107	2.8000	0	-6.0536e-09	391	514278	0	0	0
21	-8.1468e-09	1.1786e-10	1107	3.4000	0	-4.1910e-09	539	511206	0	0	0
22	-7.7957e-09	-2.2680e-10	1107	4	0	-1.0710e-08	769	516948	0	0	0
23	-8.1146e-09	1.9108e-10	1107	0	0	-6.9849e-09	362	511410	0	0	0
24	-7.9600e-09	-2.8751e-10	1107	2.8000	0	-7.4506e-09	452	511218	0	0	0
25	-8.4079e-09	1.4179e-10	1107	2	0	-5.5879e-09	156	511380	0	0	0

Figure 3. Screenshot 3 of Reading RINEX Navigation Data

4.2 Observation File

The below screenshots shows the output of the above-mentioned MATLAB observation scripts. The output is a 1x23209 data structure, which contains: *PRN, year, month, day, hour, minute, second, epoch flag, data, time in GPS and the selected C1 epoch's GPS data* (it is required to use program code to read one epoch's GPS data).

Editor - LSGI3322_20016345D_Read_ObsFile.m | Variables - Obs

nav | Obs

1x23209 struct with 11 fields

Fields	PRN	Year	Month	Day	Hour	Minute	Second	Epoch_Flag	Date_numerical	Time_in_GPS	C1
1	10	2001	3	31	0	0	0	0	730941	518400	2.3689e+07
2	22	2001	3	31	0	0	0	0	730941	518400	2.2541e+07
3	17	2001	3	31	0	0	0	0	730941	518400	2.0429e+07
4	15	2001	3	31	0	0	0	0	730941	518400	2.0782e+07
5	18	2001	3	31	0	0	0	0	730941	518400	2.1938e+07
6	6	2001	3	31	0	0	0	0	730941	518400	2.1540e+07
7	26	2001	3	31	0	0	0	0	730941	518400	2.2252e+07
8	28	2001	3	31	0	0	0	0	730941	518400	2.4135e+07
9	23	2001	3	31	0	0	0	0	730941	518400	2.1490e+07
10	3	2001	3	31	0	0	0	0	730941	518400	2.4464e+07
11	10	2001	3	31	0	0	30	0	7.3094e+05	518430	2.3708e+07
12	22	2001	3	31	0	0	30	0	7.3094e+05	518430	2.2545e+07
13	17	2001	3	31	0	0	30	0	7.3094e+05	518430	2.0426e+07
14	15	2001	3	31	0	0	30	0	7.3094e+05	518430	2.0772e+07
15	18	2001	3	31	0	0	30	0	7.3094e+05	518430	2.1921e+07
16	6	2001	3	31	0	0	30	0	7.3094e+05	518430	2.1554e+07
17	26	2001	3	31	0	0	30	0	7.3094e+05	518430	2.2243e+07
18	28	2001	3	31	0	0	30	0	7.3094e+05	518430	2.4123e+07
19	23	2001	3	31	0	0	30	0	7.3094e+05	518430	2.1478e+07
20	3	2001	3	31	0	0	30	0	7.3094e+05	518430	2.4444e+07
21	10	2001	3	31	0	1	0	0	7.3094e+05	518460	2.3728e+07
22	22	2001	3	31	0	1	0	0	7.3094e+05	518460	2.2549e+07
23	17	2001	3	31	0	1	0	0	7.3094e+05	518460	2.0423e+07
24	15	2001	3	31	0	1	0	0	7.3094e+05	518460	2.0762e+07
25	18	2001	3	31	0	1	0	0	7.3094e+05	518460	2.1904e+07

Figure 4. Screenshot of Reading RINEX Observation Data

5 Conclusion and Future Planning

In this first intermediate period, it has completed the readings of both navigation and observation RINEX data, by opening their data structure in MATLAB workplace, in table format with the corresponding headings.

For the upcoming progress, it is required to complete the calculation of GPS satellite position. As long as both navigation and observation data are read, the components regarding orbit and satellite positioning computation can be carried out. For instance, time ephemerides (tk), time correction (t), mean anomaly (M), true anomaly (theta), mean motion (n), corrected inclination (i), corrected radius (r), corrected argument of latitude (phi), second order of Harmonic perturbation and terrestrial coordinates transformation.

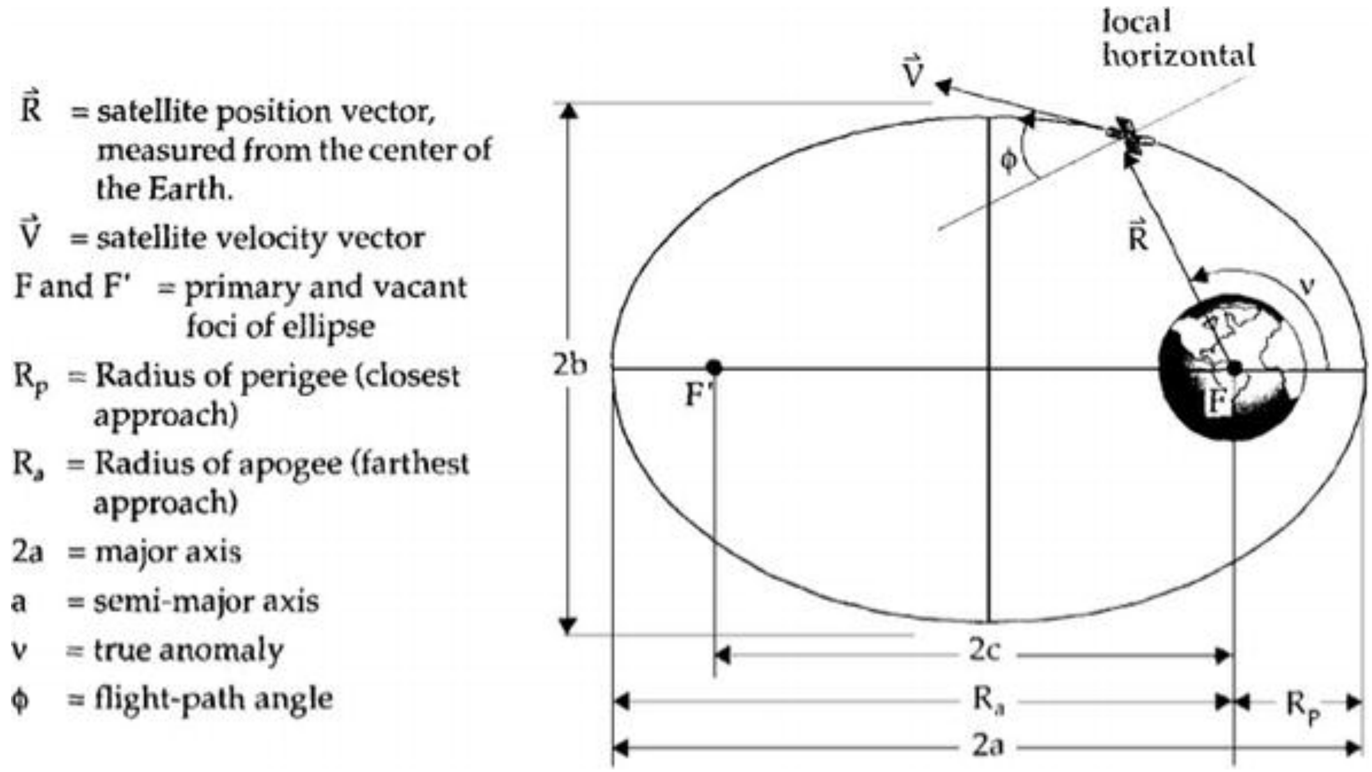


Figure 5. Several components regarding the orbit and satellite positioning components.

Reference List

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Travis H. (2019). Introduction to Satellite Attitude Control., InTech Open Book. Series.

--- THIS IS THE END OF THE FIRST INTERMEDIATE REPORT. THANK YOU. ---