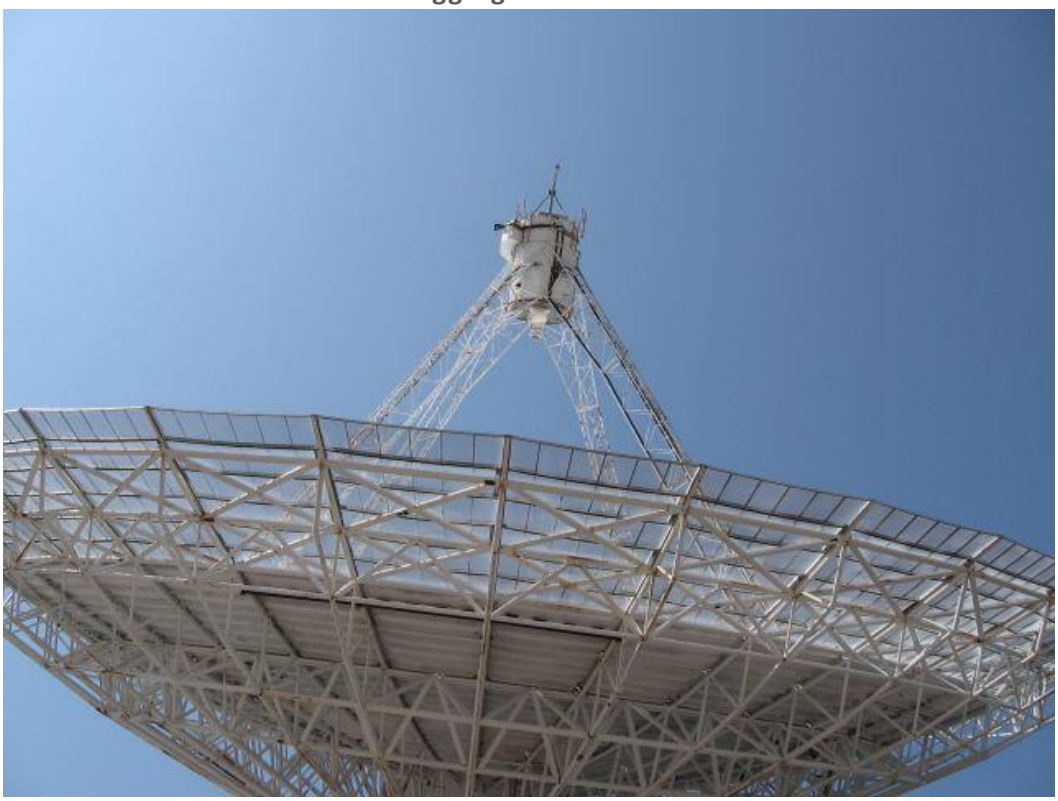
ENG 4350 6.0 FW16/17- Space Hardware

Lab P5 – Integrating high level subroutine/functions into the main program and debugging the software



Submitted by:

Keith Menezes & James Brook

Submitted to:

Prof. Hugh Chesser

Contents

Purpose

The purpose of this report is to demonstrate the integration of all high-level functions into the main to perform an end-to-end test.

Fixes – Software/Code

The following functions have been altered for enhanced performance and compatibility with the rest of our main code.

- THETAN()

Customized the THETAN function such that it takes two parameters, the TLE epoch and the starting date of our tracking schedule. Inside the function we utilize an internal function in the DateAndTimeCalculations.c to calculated the Julian date at epoch.

Subsequently the header file was changed to include the extra input.

```
29      - double THETAN(double TLEepoch){
30      -     double num = TLEepoch;
31      -     num = TLEepoch/1000;
32      -     double year = num - frac(num);
33      -     double day = TLEepoch - year*1000;
34      -     double yearf = year + 2000;
35      -     double JDy = jdaty(yearf);
36      -     double JD = JDy + day -1;
37      -     double rads = THETAJ(JD);
        29  + double THETAN(double TLEepoch, double JDstart){
        30  +     double JD;
        31  +     JD = jdatep(TLEepoch);
        32  +     double rads = THETAJ(JD, JDstart);
38      33      return rads;
```

- THETAJ()

```
41      - double THETAJ (double JulianDate){
        36  + double THETAJ (double JulianDate, double JulianDateStart){
42      37      double JDm;
43      -     if(JulianDate>=floor(JulianDate) + 0.5){JDm = floor(JulianDate) + 0.5;}
44      -     else{JDm = floor(JulianDate) - 0.5;}
45      -     double Du = JulianDate - 2451545.0;
        38  +     if(JulianDateStart>=floor(JulianDateStart) + 0.5){JDm = floor(JulianDateStart) + 0.5;}
        39  +     else{JDm = floor(JulianDateStart) - 0.5;}
        40  +     double Du = JDm - 2451545.0;
46      41      double Tu = Du / 36525.0;
47      42      double GMST = 24110.54841 + 8640184.812866*Tu + 0.093104*Tu*Tu - 0.0000062*Tu*Tu*Tu;
48      43      for (;GMST > 86400;){
```

The THETAJ function had to be changed to accommodate the tracking schedule start date as an input. In the if-statement the tracking date is used as the comparative, the rest of the code remains the same, but now the function returns the GMST angle in radians for the specific Julian date.

- Added link signal strength to the main()

The signal strength has been added to the AOS/LOS table where an array is created to hold the signal strength of each satellite in the table. The formatting of the table was altered so that it displays as specified in the Tracking Specifications and on the user console.

```
350       -
          350 +     double ss[31];
351       351       for(int j=1; j<32; j++){//Run through each satellite
352       352
353       353           double currentTime;
...       ...     @@ -377,7 +377,7 @@ int main(void){
395       -             double ss[31];
396       -             //ss[num] = linkstrength(rtPos->mag);
          395 +
          396 +             ss[num] = linkstrength(rtPos->mag);
397       397             if (LA->elevation <= stn->az_el_lim.elmax && LA->elevation >= stn->az_el_lim.elmin && acquired == 0){//Go in to this loop if the
                          satellite is acquired.
398       398                 //If the satellite has already been acquired then don't add it again
399       399                 NUM[num] = j;
...       ...     @@ -418,10 +418,11 @@ int main(void){
418       418       fprintf(filepoint, "Sat No.            Name                AOS                 LOS                 Min. ExpectedLevel (dBm)\n");
419       419       for(int i=0;i<num;i++){
420       420           printf("%d    %s %s   ", NUM[i], NAME[i], jd2dat(AOS[i]));
421       -           printf("%s\n", jd2dat(LOS[i]));
          421 +           printf("%s", jd2dat(LOS[i]));
          422 +           printf("\t%f\n",ss[i]);
422       423           fprintf(filepoint, "%d        %s   %s   ", NUM[i], NAME[i], jd2dat(AOS[i]));
423       424           fprintf(filepoint, "%s", jd2dat(LOS[i]));
424       -       //  fprintf(filepoint,"%f\n",linkstrength(rtPos->mag));
          425 +       fprintf(filepoint,"   %f\n",ss[i]);
425       426       }
426       427       fclose(filepoint);
427       428       return 0;
```

Software Advancements

This section shows the advancements we made with the fixes in our code and confirmed with STK to approve.

AOS/LOS Data

Here is what the AOS/LOS table looks like with the expected signal strength:

Sat No.	Name	AOS	LOS	Min. ExpectedLevel (dBm)
0	GPS BIIR-2 (PRN 13)	2017-03-19 00:00:00	2017-03-19 00:59:59	-194.751455
2	GPS BIIR-4 (PRN 20)	2017-03-19 00:00:00	2017-03-19 00:59:59	-191.842836
3	GPS BIIR-5 (PRN 28)	2017-03-19 00:00:00	2017-03-19 00:59:59	-209.598671
4	GPS BIIR-6 (PRN 14)	2017-03-19 00:00:00	2017-03-19 00:59:59	-194.866402
7	GPS BIIR-9 (PRN 21)	2017-03-19 00:49:59	2017-03-19 00:59:59	-191.745841
11	GPS BIIR-13 (PRN 02)	2017-03-19 00:00:00	2017-03-19 00:59:59	-191.760244
12	GPS BIIRM-1 (PRN 17)	2017-03-19 00:00:00	2017-03-19 00:59:59	-204.384352
16	GPS BIIRM-5 (PRN 29)	2017-03-19 00:00:00	2017-03-19 00:59:59	-203.887205
19	GPS BIIF-1 (PRN 25)	2017-03-19 00:00:00	2017-03-19 00:59:59	-208.525202
20	GPS BIIF-2 (PRN 01)	2017-03-19 00:00:00	2017-03-19 00:59:59	-191.225996
22	GPS BIIF-4 (PRN 27)	2017-03-19 00:00:00	2017-03-19 00:59:59	-205.369155
23	GPS BIIF-5 (PRN 30)	2017-03-19 00:00:00	2017-03-19 00:59:59	-195.516778
24	GPS BIIF-6 (PRN 06)	2017-03-19 00:54:59	2017-03-19 00:59:59	-190.791992
25	GPS BIIF-7 (PRN 09)	2017-03-19 00:00:00	2017-03-19 00:59:59	-195.258373
27	GPS BIIF-9 (PRN 26)	2017-03-19 00:00:00	2017-03-19 00:59:59	-208.562454
29	GPS BIIF-11 (PRN 10)	2017-03-19 00:00:00	2017-03-19 00:59:59	-191.842144

Tracking Data

For the final roll, out of our software the Tracking Data table, as specified in 5.2 of Tracking Specifications lab manual. After the AOS/LOS table is calculated we:

1. Prompt the user to select a satellite to track from the AOS/LOS table
2. Use the satellite TLE parameters to calculate
    a. sat_ECI() to find the satellite ECI position and velocity

b. sat_ECF() to find the satellite ECF position and velocity
c. station_ECF() to find the station position
d. range_ECF2topo() to find the position and velocity
e. Range_topo2look_angles() to find the position and velocity angles and range from the topocentric coordinate system.

```
@@ -439,11 +439,17 @@ int main(void){
     fflush(stdout);
     scanf("%d", &satNum);
     Satellite sat = sats[satNum+1];
+    FILE *xp;
+    xp = fopen("TrackingData.txt", "w+");
     printf("\n----------------------------------------------------------------------------------------------------------------------------------------------------------------
     \n");
     printf("UTC\t\t\tAZ\t\tEL\t\tAZ-vel\t\tEL-vel\t\tRange\t\tRange-Rate\t\tDoppler\t\tLevel\n");
     printf("\t\t\tdeg\t\tdeg\t\tdeg/sec\t\tdeg/sec\t\tkm\t\tkm/sec\t\t\tkHz\t\tdbm\n");
     printf("----------------------------------------------------------------------------------------------------------------------------------------------------------------\n");

+    fprintf
+    (xp,"\n----------------------------------------------------------------------------------------------------------------------------------------------------------------\n");
+    fprintf(xp,"UTC\t\t\tAZ\t\tEL\t\tAZ-vel\t\tEL-vel\t\tRange\t\tRange-Rate\t\tDoppler\t\tLevel\n");
+    fprintf(xp,"\t\t\tdeg\t\tdeg\t\tdeg/sec\t\tdeg/sec\t\tkm\t\tkm/sec\t\t\tkHz\t\tdbm\n");
+    fprintf(xp,"----------------------------------------------------------------------------------------------------------------------------------------------------------------
+    \n");

     double currentTime;
     currentTime = JulianDateStart;
@@ -491,9 +497,8 @@ int main(void){
         ss[num] = linkstrength(rtPos->mag);

         printf("%s\t%f\t%f\t%f\t%f\t%f\t%f\t\t\t\t\t%f\n", jd2dat(currentTime),LA->azimuth,LA->elevation,LA->azimuth_velocity,LA->elevation_velocity,sqrt(rtPos->x*rtPos->x+rtPos->y*rtPos->y+rtPos->z*rtPos->z),sqrt(rtVel->x*rtVel->x+rtVel->y*rtVel->y+rtVel->z*rtVel->z),linkstrength(rtPos->mag));
-
-
+        fprintf(xp,"%s\t%f\t%f\t%f\t%f\t%f\t%f\t\t\t\t\t%f\n", jd2dat(currentTime),LA->azimuth,LA->elevation,LA->azimuth_velocity,LA->elevation_velocity,sqrt(rtPos->x*rtPos->x+rtPos->y*rtPos->y+rtPos->z*rtPos->z),sqrt(rtVel->x*rtVel->x+rtVel->y*rtVel->y+rtVel->z*rtVel->z),linkstrength(rtPos->mag));
     }
-
+    fclose(fp);
     return 0;
 }
```

Here is what it looks like on the console. Simultaneously it is printed to a file named TrackingData.txt

```
Enter the satellite number you would like to track from the table (values in the first column): 0

-------------------------------------------------------------------------------------------------------------------------------------------------------------------
UTC                     AZ              EL              AZ-vel          EL-vel          Range           Range-Rate              Doppler         Level
                        deg             deg             deg/sec         deg/sec         km              km/sec                  kHz             dbm
-------------------------------------------------------------------------------------------------------------------------------------------------------------------
2017-03-19 00:00:00     64.726728       -22.897671      -0.000077       0.000122        25275.710905    3.159979                                -195.507249
2017-03-19 00:04:59     63.049901       -20.904136      -0.000074       0.000123        25254.013698    3.168479                                -195.490073
2017-03-19 00:09:59     61.425865       -18.877012      -0.000071       0.000123        25231.991827    3.175170                                -195.472625
2017-03-19 00:14:59     59.845971       -16.822333      -0.000069       0.000123        25209.710261    3.179985                                -195.454956
2017-03-19 00:19:59     58.301721       -14.745881      -0.000067       0.000123        25187.235078    3.182878                                -195.437117
2017-03-19 00:24:59     56.784793       -12.653233      -0.000066       0.000123        25164.633298    3.183824                                -195.419162
2017-03-19 00:29:59     55.287049       -10.549811      -0.000065       0.000122        25141.972669    3.182816                                -195.401144
2017-03-19 00:34:59     53.800529       -8.440934       -0.000065       0.000120        25119.321487    3.179866                                -195.383117
2017-03-19 00:39:59     52.317447       -6.331862       -0.000065       0.000118        25096.748393    3.175008                                -195.365137
2017-03-19 00:44:59     50.830177       -4.227848       -0.000065       0.000115        25074.322160    3.168297                                -195.347257
2017-03-19 00:49:59     49.331244       -2.134176       -0.000066       0.000111        25052.111478    3.159804                                -195.329533
2017-03-19 00:54:59     47.813313       -0.056207       -0.000067       0.000107        25030.184737    3.149623                                -195.312021
2017-03-19 00:59:59     46.269192       2.000580        -0.000069       0.000101        25008.609817    3.137867                                -195.294774
```

Conclusion

Our software has demonstrated the integration of all the functions required to track the GNSS satellites.