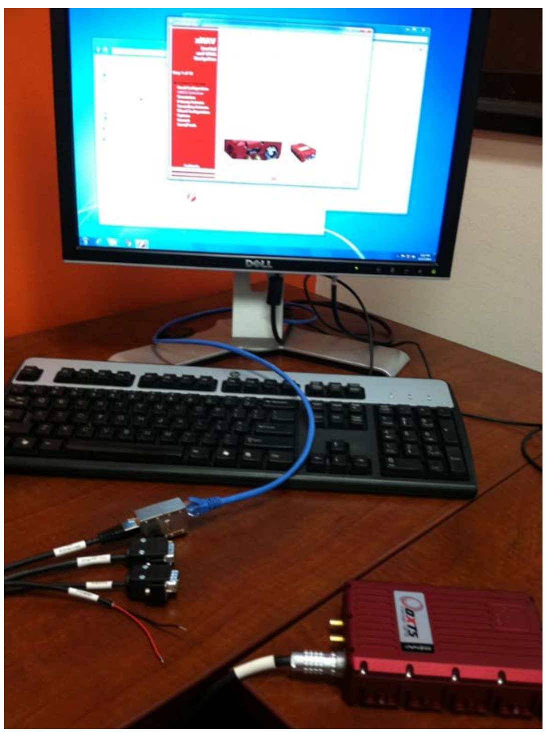
Kinematic Positioning and Navigation – Winter 2018: Homework #1

Trajectory Processing and Analysis

Overview: in this homework assignment, you will post-process the trajectory from the S1000 lidar-UAS flights from the first day of class. The only step that has been completed for you is that the raw data file (.rd file) has been downloaded from the xNAV 200 (the unit flown on the DJI S1000 remote aircraft in class), as shown below:

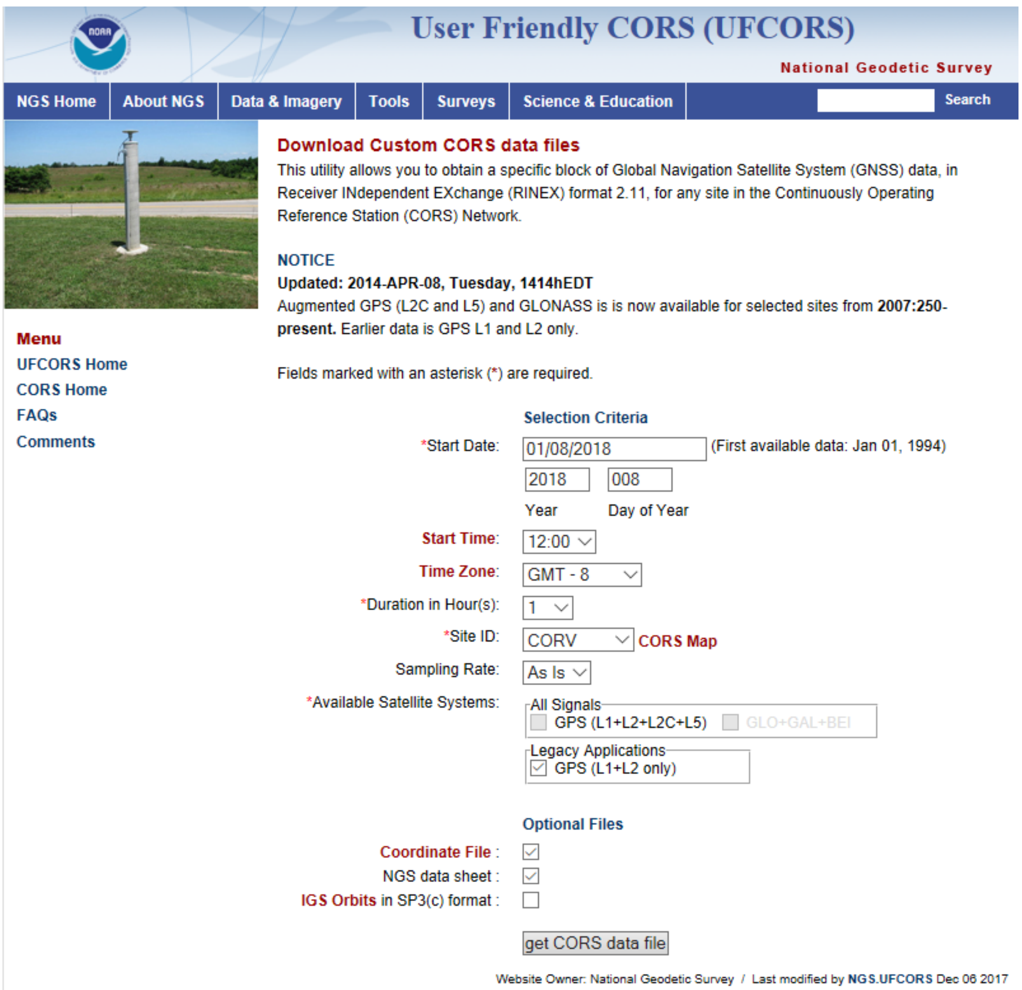


Transferring data from xNAV to computer. (Note: this step has already been completed for you.)

Complete the listed steps under each section. When done, answer the questions which are at the end of this HW assignment sheet and submit your answers on Canvas.

Part 1: Obtaining data files and performing pre-processing

- Download the file 180108_202208.rd from the course Canvas site. This file was generated by the OxTS xNAV 200 GNSS-aided INS system that was flown on the UAS on the first day of class: http://www.oxts.com/products/xnav/
  - Note that the file naming convention for this file is: yymmdd_hhmmss.rd, where "yy" is the year, "mm" is the month, "dd" is the day, "hh" is the hour, "mm" is the minutes and "ss" is the seconds.
- The base station to use in post processing is a National Geodetic Survey (NGS) Continuously Operating Reference Station (CORS) called "CORV." To obtain the RINEX observation file (briefly described here: https://en.wikipedia.org/wiki/RINEX) for this site, go to the National Geodetic Survey (NGS) User Friendly CORS site: https://www.ngs.noaa.gov/UFCORS/
- Complete the fields as shown (making sure to double check the time zone), and then hit 'get CORS data file':



- Unzip the downloaded file to your working directory for this HW.

- Next, you will need to edit the CORV RINEX file header to input the published NAD 83 (2011) epoch 2010.00 L1 phase center values. To do so, first locate the file called corv0080.18o that you just downloaded, and open it in a text editor, such as Notepad++
- Edit the following line in the header

```
tegc.e edited: all QZSS satellites excluded                 COMMENT
CORV                                                        MARKER NAME
49659M001                                                   MARKER NUMBER
Goldfinger, Chris   Oregon State University                 OBSERVER / AGENCY
4527253291          TRIMBLE NETRS       1.3-0               REC # / TYPE / VERS
CR1998490176        ASH700936E_C    UNAV                    ANT # / TYPE
 -2498423.1090 -3802822.0340  4454737.7580                  APPROX POSITION XYZ
        1.5210        0.0000        0.0000                  ANTENNA: DELTA H/E/N
     1     1                                                WAVELENGTH FACT L1/2
     8    L1    L2    C1    C2    P1    P2    S1    S2      # / TYPES OF OBSERV
     1.0000                                                 INTERVAL
tegc.w windowed: start @ 2018 Jan  8 20:00:00.000           COMMENT
tegc.w windowed:  end  @ 2018 Jan  8 21:00:00.000           COMMENT
tegc.w edited: all GLONASS satellites excluded              COMMENT
  2018     1     8    20     0    0.0000000     GPS         TIME OF FIRST OBS
                                                            END OF HEADER
```

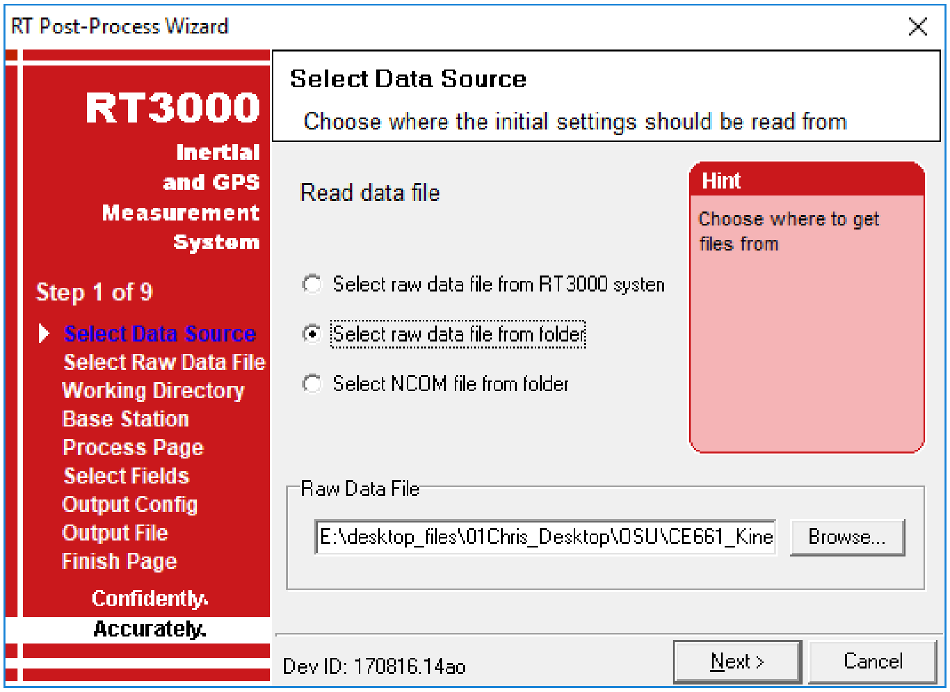
New values:

X	-2498423.1450
Y	-3802822.0880
Z	4454737.8230

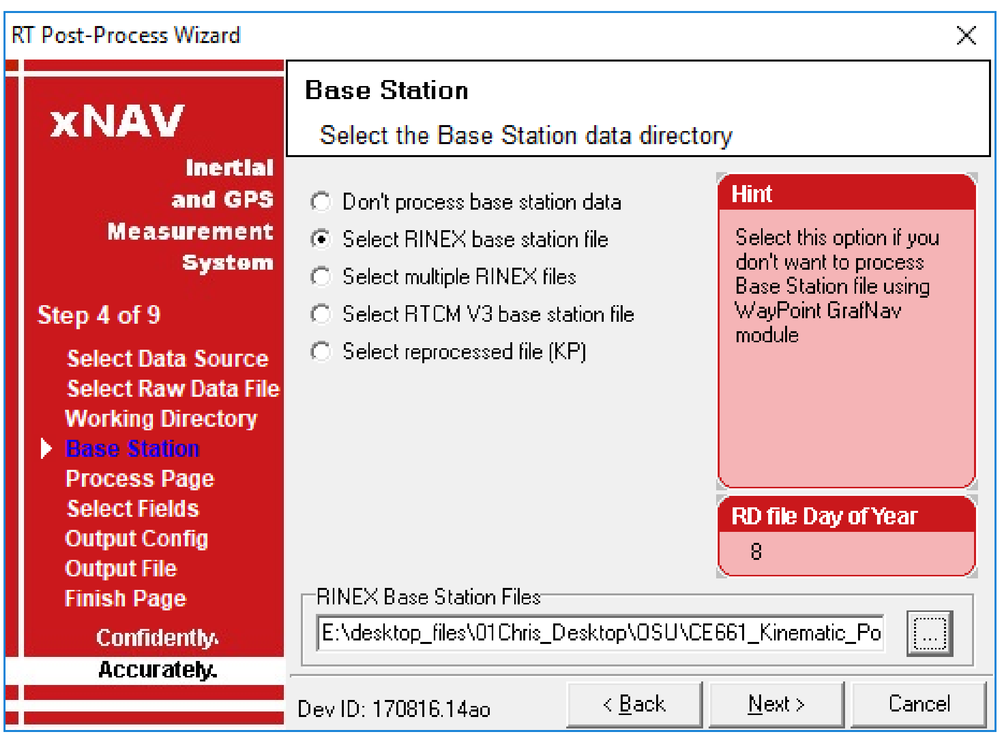
You can just copy and paste these new values into the file, or type over the existing values and then save the file. (Note that these values are in meters and the changes are at the cm level, so fairly small, but not negligible.)

Part 2: Generating the trajectory

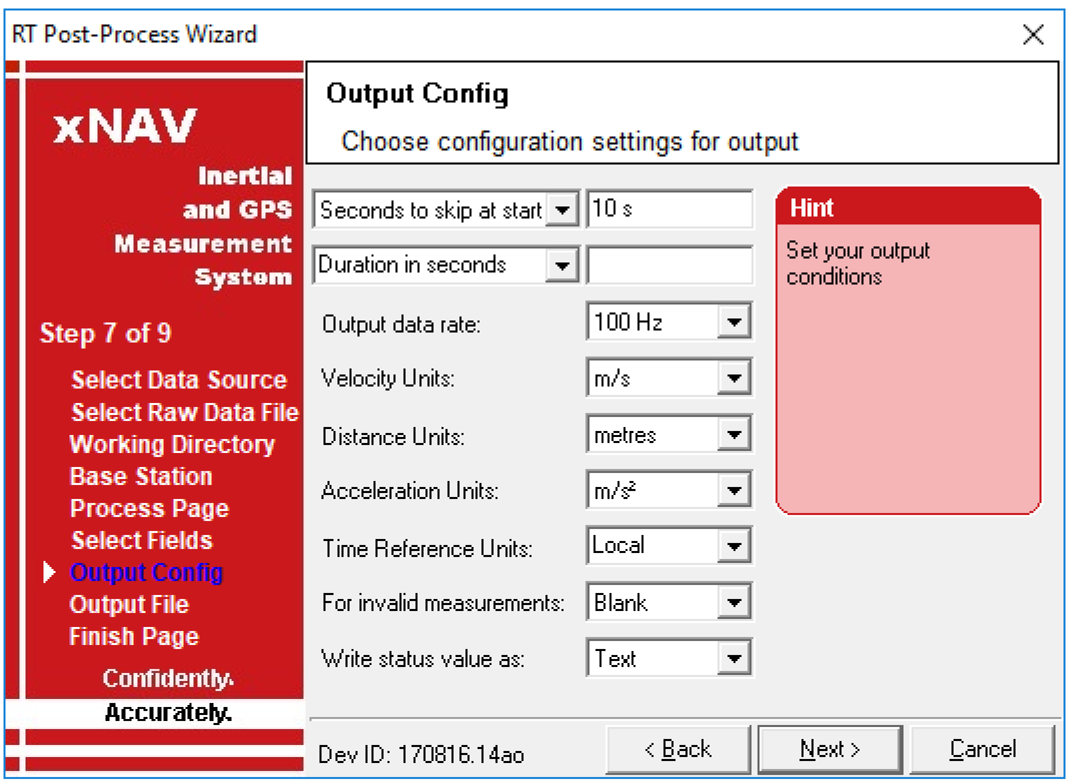
- Launch the application **RT Post-Process**.
    - Note: this program is installed on the computers in Owen 217 (CCE Photogrammetry Lab). However, if you'd prefer to run it on your own computer, it can be obtained here: https://support.oxts.com/hc/en-us/sections/115000789105-NAVsuite
- In the Select Data Source window, choose the "Select raw data from folder option" and browse to find and select the .rd file that you obtained from the class Canvas site, as shown below:



- In the Working Directory window, set your working directory to whatever local folder you're using for this HW exercise, and check the box "Extract Config Files from RD File."
- In the Base Station window, check the box for "Select RINEX base station file," then browse to find the RINEX file from for Station CORV that you downloaded and edited in Part 1: corv0080.18o



- In the Process Page window, select: Combine (Forwards + Backwards). This processes the INS data forwards and backwards in time, improving accuracy. Also check Clean-up directory after processing.
- Click Process. (The processing may take ~2 minutes to complete, during which time you can view the output being written to the DOS window, which should pop up.)
- Set the output file format to .csv and select the following fields:
    - Date
    - Time of day
    - Pos (Latitude,Longitude,Altitude)
    - Vel (North,East,Down)
    - Speed
    - Accel (X,Y,Z)
    - Angle (Heading, Pitch, Roll)
    - AngRate (X,Y,Z)
    - PosStdev (North,East,Down)
    - AngleHeadingStdev
    - AngleStdev (Pitch,Roll)
- Use the options shown below for the output:

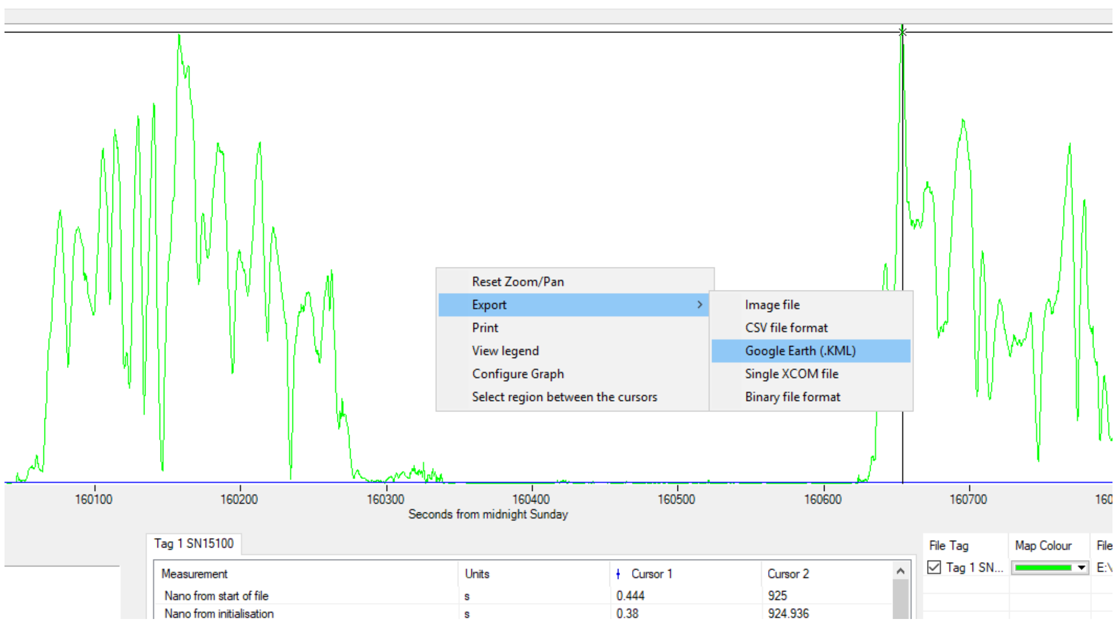


- In the Output File window, check Export to Main Output file, and make sure the csv file is being saved to your HW folder. Then click Export.

- You should see a “Finish Page” telling you that the csv file (e.g., 180108_202208.csv) has been created in your working folder. At this point, you can just click on Finish.

<u>Part II: Trajectory analysis and display in Excel, NAVgraph and Google Earth</u>

- Start the program called NAVgraph, which is also part of the OxTS nav suite
- On the right hand side of the NAVgraph window, click on the open file icon 
- Browse to your HW folder and select the .ncom file, which you just created in the previous step.
- Experiment with the functionality in NAVgraph, including moving the cursor in the map view to examine the measurement data.
- Right click in the Axis1 plot and click Export and then select Google Earth .KML



- Make sure your HW folder is still selected and click Ok to save the kml file
- Open the KML file in Google Earth
- Find the .csv file that was created in RT PostProcess and open it in Excel. Look through the fields to ensure you understand the contents.
- Based on examining the trajectory in Google Earth and Excel answer the questions below to complete your HW submission.
  - Note: the computations (e.g., means of the different parameters) and plots can be generated in Excel or MATLAB. (Or, if you want to use something else, such as Python, that’s fine, too.) If you decide to use MATLAB, I created a sample script called HW1.m (on course Canvas site) that may be useful. However, you will need to modify it, based on your filenames and paths, etc.

<u>Questions and required plots for HW submission:</u>

1. **In Google Earth, create an output map (Save, Output Image, …) of the UAS trajectory to include with your HW submission. Be sure to include a map title, scale bar and north arrow.**
2. **What do you think was the purpose of the figure 8s at the beginning of the trajectory?**
3. **What are the mean and standard deviation of the Roll, Pitch, and Heading values in the POS file? Do these values make sense for the UAS flight? For example, would you expect the standard deviation of heading to be larger than the standard deviation of roll and pitch? Why?**
4. **What was the mean 3D speed of the vehicle over the trajectory? Does this value make sense, based on having watched the UAS flights?**
5. **Create the following plots**
    a. **Roll vs. time**
    b. **Pitch vs. time**
    c. **Heading vs. time**
    d. **σ_{roll} vs. time**
    e. **σ_{pitch} vs. time**
    f. **$\sigma_{heading}$ vs. time**
6. **What could have caused the roll, pitch, and heading uncertainties to be higher for some parts of the trajectory than others?**
7. **Between roll, pitch, and heading, which has the largest uncertainty? Is this consistent with the manufacturers' specs for other direct georeferencing systems discussed in the first lecture?**

When you've answered the above, upload your HW to Canvas.

Additional references for this HW:

- OxTS RT Post Process Manual: https://support.oxts.com/hc/en-us/articles/115002433385-RT-Post-Process-Online-manual
- OxTS NAVgraph Manual: https://support.oxts.com/hc/en-us/articles/115002433465-NAVgraph-Online-manual