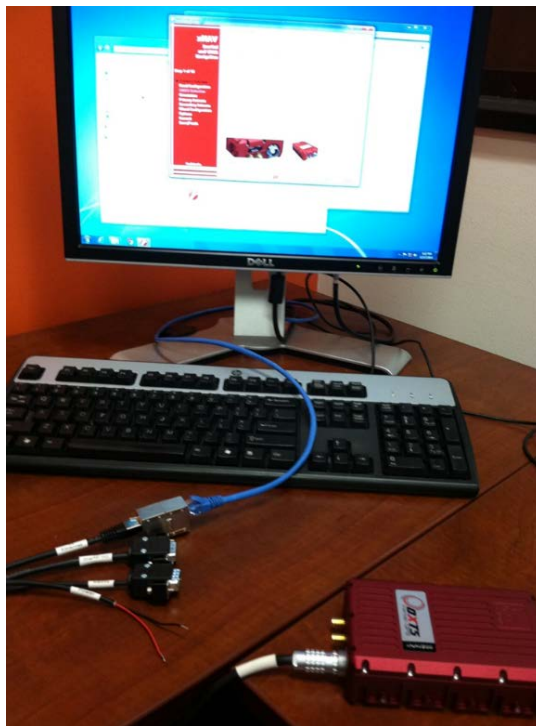


Kinematic Positioning and Navigation – Winter 2018: Homework #1

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:

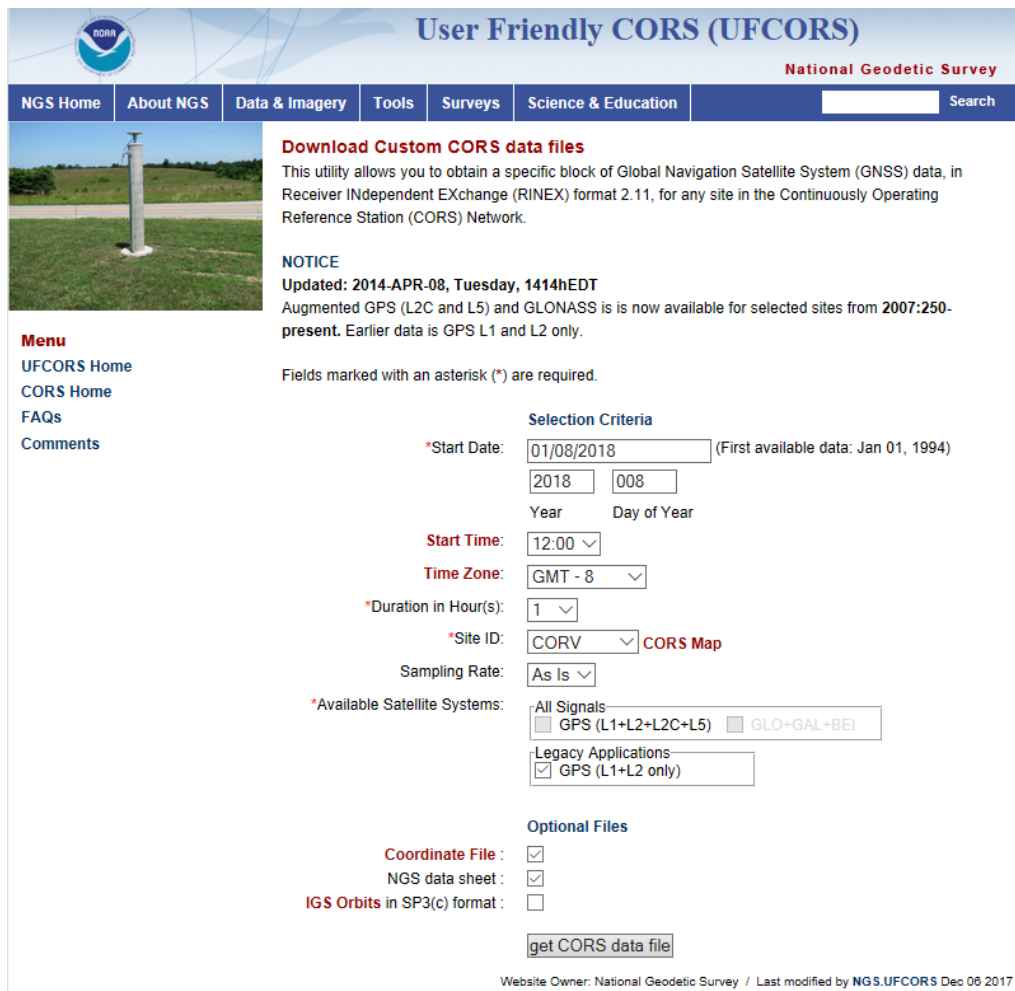


Transferring
data from xNAV
to computer.
(Note: this step
has already
been completed
for you.)

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’:



The screenshot shows the 'User Friendly CORS (UFCORS)' website interface. The header includes the NOAA logo and navigation links: NGS Home, About NGS, Data & Imagery, Tools, Surveys, Science & Education, and a search bar. A sidebar menu on the left contains links to UFCORS Home, CORS Home, FAQs, and Comments. The main content area is titled 'Download Custom CORS data files' and includes a notice about data availability (updated 2014-APR-08) and a note that fields marked with an asterisk (*) are required. The form contains several sections: 'Selection Criteria' with fields for Start Date (01/08/2018), Start Time (12:00), Time Zone (GMT - 8), Duration in Hour(s) (1), Site ID (CORV), and Sampling Rate (As Is); 'Available Satellite Systems' with checkboxes for GPS (L1+L2+L2C+L5), GLO+GAL+BEL, and Legacy Applications (GPS (L1+L2 only)); and 'Optional Files' with checkboxes for Coordinate File, NGS data sheet, and IGS Orbits in SP3(c) format. A 'get CORS data file' button is at the bottom.

User Friendly CORS (UFCORS)
National Geodetic Survey

NGS Home About NGS Data & Imagery Tools Surveys Science & Education Search

Download Custom CORS data files
This utility allows you to obtain a specific block of Global Navigation Satellite System (GNSS) data, in Receiver INdependent EXchange (RINEX) format 2.11, for any site in the Continuously Operating Reference Station (CORS) Network.

NOTICE
Updated: 2014-APR-08, Tuesday, 1414hEDT
Augmented GPS (L2C and L5) and GLONASS is now available for selected sites from 2007:250-present. Earlier data is GPS L1 and L2 only.

Fields marked with an asterisk (*) are required.

Menu
UFCORS Home
CORS Home
FAQs
Comments

Selection Criteria

*Start Date: 01/08/2018 (First available data: Jan 01, 1994)
2018 008
Year Day of Year

Start Time: 12:00
Time Zone: GMT - 8

*Duration in Hour(s): 1

*Site ID: CORV [CORS Map](#)

Sampling Rate: As Is

*Available Satellite Systems:
All Signals
☐ GPS (L1+L2+L2C+L5) ☐ GLO+GAL+BEL
Legacy Applications
☒ GPS (L1+L2 only)

Optional Files

Coordinate File : ☒
NGS data sheet : ☒
IGS Orbits in SP3(c) format : ☐

[get CORS data file](#)

Website Owner: National Geodetic Survey / Last modified by NGS.UFCORS Dec 08 2017

- 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

```

21 teqc.e edited: all QZSS satellites excluded COMMENT
22 CORV MARKER NAME
23 49659M001 MARKER NUMBER
24 Goldfinger, Chris Oregon State University OBSERVER / AGENCY
25 4527253291 TRIMBLE NETRS 1.3-0 REC # / TYPE / VERS
26 CR1998490176 ASH700936E_C UNAV ANT # / TYPE
27 -2498423.1090 -3802822.0340 4454737.7580 APPROX POSITION XYZ
28 1.5210 0.0000 0.0000 ANTENNA: DELTA H/E/N
29 1 1 WAVELENGTH FACT L1/2
30 8 L1 L2 C1 C2 P1 P2 S1 S2 # / TYPES OF OBSERV
31 1.0000 INTERVAL
32 teqc.w windowed: start @ 2018 Jan 8 20:00:00.000 COMMENT
33 teqc.w windowed: end @ 2018 Jan 8 21:00:00.000 COMMENT
34 teqc.w edited: all GLONASS satellites excluded COMMENT
35 2018 1 8 20 0 0.0000000 GPS TIME OF FIRST OBS
36 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:

RT Post-Process Wizard

RT3000
Inertial
and GPS
Measurement
System

Step 1 of 9
▶ **Select Data Source**
Select Raw Data File
Working Directory
Base Station
Process Page
Select Fields
Output Config
Output File
Finish Page

Confidently.
Accurately.

Select Data Source

Choose where the initial settings should be read from

Read data file

☐ Select raw data file from RT3000 system
☒ Select raw data file from folder
☐ Select NCOM file from folder

Raw Data File

E:\desktop_files\01Chris_Desktop\OSU\CE661_Kine Browse...

Dev ID: 170816.14ao

Next > Cancel

Hint
Choose where to get files from

- 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

RT Post-Process Wizard

xNAV
Inertial
and GPS
Measurement
System

Step 4 of 9
Select Data Source
Select Raw Data File
Working Directory
▶ **Base Station**
Process Page
Select Fields
Output Config
Output File
Finish Page

Confidently.
Accurately.

Base Station

Select the Base Station data directory

☐ Don't process base station data
☒ Select RINEX base station file
☐ Select multiple RINEX files
☐ Select RTCM V3 base station file
☐ Select reprocessed file (KP)

RINEX Base Station Files

E:\desktop_files\01Chris_Desktop\OSU\CE661_Kinematic_Po

Dev ID: 170816.14ao

< Back Next > Cancel

Hint
Select this option if you don't want to process Base Station file using WayPoint GrafNav module

RD file Day of Year
8

- 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:

RT Post-Process Wizard

xNAV
Inertial and GPS Measurement System

Step 7 of 9

- Select Data Source
- Select Raw Data File
- Working Directory
- Base Station
- Process Page
- Select Fields
- Output Config**
- Output File
- Finish Page

Confidently. Accurately.

Output Config
Choose configuration settings for output

Seconds to skip at start: 10 s

Duration in seconds:

Output data rate: 100 Hz

Velocity Units: m/s

Distance Units: metres

Acceleration Units: m/s²

Time Reference Units: Local

For invalid measurements: Blank

Write status value as: Text

Hint
Set your output conditions


Dev ID: 170816.14ao

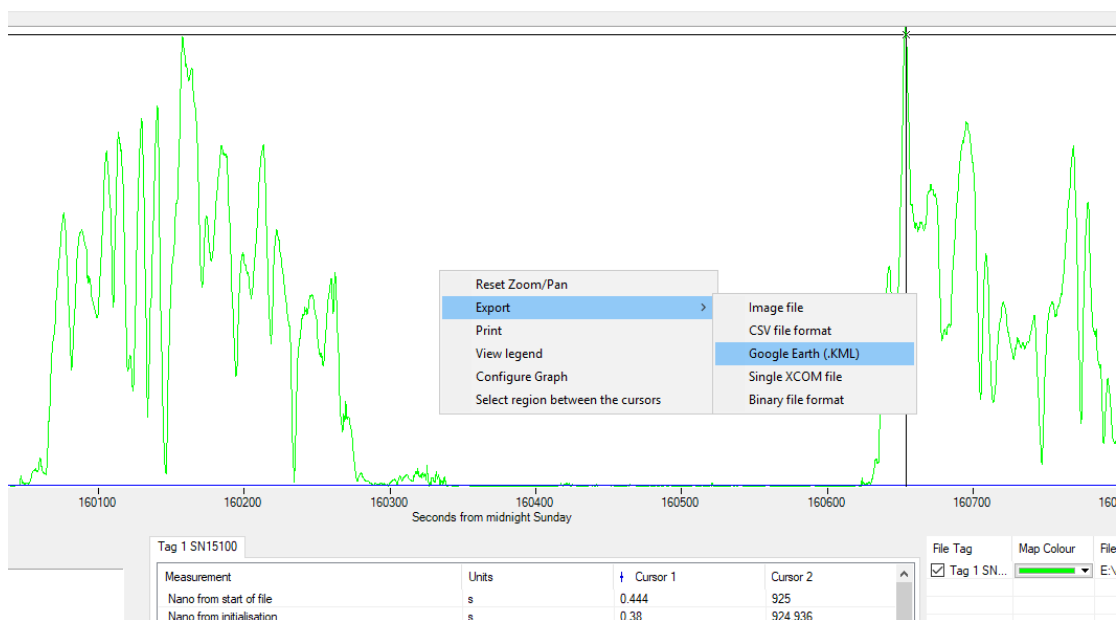
< Back Next > Cancel

- 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.

Part II: Trajectory analysis and display in Excel, NAVgraph and Google Earth

- 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.

Questions and required plots for HW submission:

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. σ_{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>